WESTON 1242 DMM

MP MASTER
MA35433

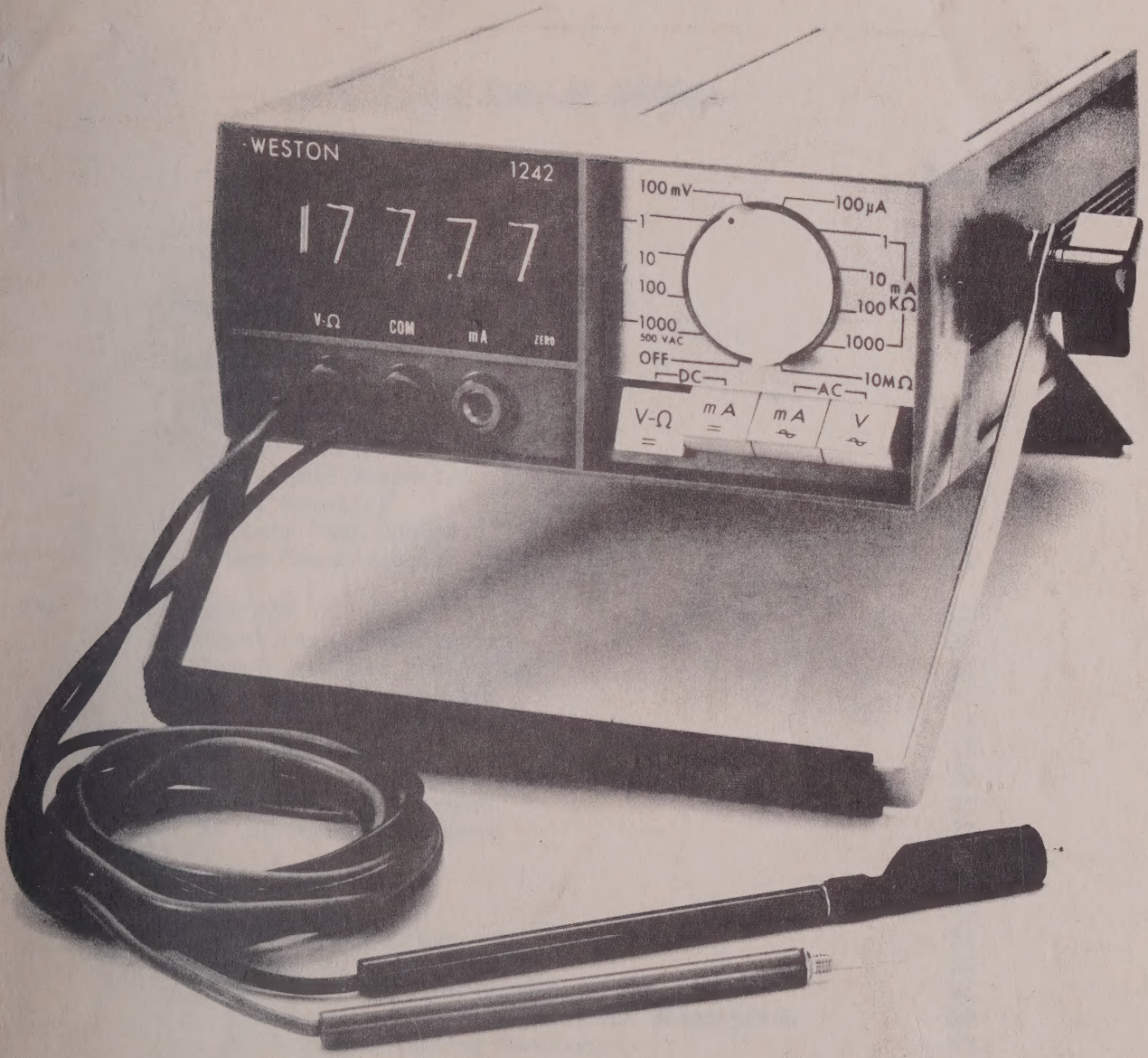

Figure 1. Model 1242 Digital Multimeter with Handle/Stand and Test Probes

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GENERAL INFORMATION

DESCRIPTION.

The Weston Model 1242 is a compact digital multimeter designed for maximum operator convenience and utility. Five voltage and five current ranges, both AC and DC, as well as five resistance ranges are self-contained in a high-impact resistant plastic case.

The basic measuring circuit is a bipolar analog to digital converter which employs dual-slope integration to achieve excellent accuracy and long term stability. Full scale display is 10,000 digits and an overrange capability to 19,999 digits is provided, except where limited by overload. The basic measurement range is 4 volts DC. All ranges and functions are converted to the basic 4 volt DC range for measurement as a DC voltage.

A custom-designed thin-film attenuator and a switched-gain preamplifier extend DC voltage measurements from 100 MV FS to 1000 V FS.

AC voltage is converted to DC by an average - sensing, RMS - calibrated, operational rectifier which extends the AC voltage range from 100 millivolts full scale on the most sensitive range to an allowable maximum of 500 volts on the highest range.

Current is measured by the voltage drop it establishes across a precision shunt network. If DC - it is measured directly; if AC - it is first converted to DC by the operational rectifier. Currents from 0.1 microampere to 1 ampere can be measured with a voltage drop of only 100 millivolts full scale across the shunt.

Resistance is measured by passing a scaled constant current through the unknown and measuring the DC voltage across it. Resistance ranges from 1K ohms to 10 megohms are provided with a measuring current of no more than 100 microamperes.

The mechanical design of Model 1242 has stressed operator convenience and confidence in its straight-forward control/connector layout and generous overload protection. Easy portability is evident, too, in its small size, fully recessed controls, and connectors, and its battery pack compatibility for field use.

Carrying handles serve a dual purpose as a tilt-stand for any viewing angle during table top operation. The instrument may be panel mounted without any additional parts.

Optional accessories include a battery pack capable of field operation and overnight recharge, and a leather carrying case.

Power requirements are 115 VAC or 230 VAC at frequencies of 50/60/400 Hz, 8.5 watts, nominal.

SPECIFICATIONS

Size . . . . . 3" high x 7" wide x 7.9" deep

Weight . . . . . Approx. 4.5 pounds (2 Kg)

Display . . . . . Maximum Count: 19999
Overrange Indication: Automatic (beyond 19999)
Polarity Indication: Automatic (for negative DC)
Reading Rate: 10 per second, non-blink
(100 millisec integration time).
Numeric Display by side-viewing neon glow tubes
with integral decimal points.

Power Requirements . . 115 VAC or 230 VAC
Tolerance: ±15%, -10%
Line Frequency: 50 Hz to 400 Hz
Power Drain: 8.5 watts nominal

Accessories . . . . . Combination carrying handle tilt-stand - standard on all units.
Battery Pack - optional
Leather carrying case - optional

Additional Features . . . . . Input protection fuse accessible from outside of unit. May be operated 500 volts above power line ground.

Operating Temperature . . . . . 10°C to 40°C

DC VOLTS (at 23°C ±1°C and line voltage of 115 V/230 V ±10%)

Range	Zin	Rated Accuracy	Input Protection Limit
100 MV	≥ 100 MΩ	±0.05% rdg ±1 digit	500 V rms
1 V	≥ 1000 MΩ	±0.05% rdg ±1 digit	500 V rms
10 V	10 MΩ	±0.05% rdg ±1 digit	1000 V peak
100 V	10 MΩ	±0.05% rdg ±1 digit	1000 V peak
1000 V	10 MΩ	±0.05% rdg ±1 digit	1000 V peak

Overrange Capability .. 100% (to 19999) on all ranges except the 1000 V range where the allowable limit is 1000 V DC.

Resolution . . . . . 10 microvolts

Full Scale Step Response (to within 0.05% of final value) . 0.5 sec.

Input Bias Current . . . . . 2nA maximum at 25°C

Temperature Influence . . . . . ±40 PPM Rdg ±0.4 digit/°C

Normal Mode Rejection . . . . . 40 dB minimum at 60 Hz

Common Mode Rejection . . . . . 80 dB minimum with 1K unbalance at 60 Hz

RESISTANCE

Range	Test Current	Rated Accuracy	Input Protection Limit
1 K	100 µA	±0.15% rdg ±1 digit	130V rms, continuous 230V 30 sec. max.
10 K	100 µA	±0.10% rdg ±1 digit	
100 K	10 µA	±0.10% rdg ±1 digit	250 V rms
1 MΩ	1 µA	±0.25% rdg ±1 digit	250 V rms
10 MΩ	0.1 µA	±0.5% rdg ±1 digit	250 V rms

Overrange Capability . . . . . 100% (to 19999) on all ranges

Resolution . . . . . 0.1 ohm

Full Scale Step Response . . . . . less than 1 second except the 10 MΩ range where response time is six seconds at 10 MΩ.

NOTE: Short term accuracy immediately after overload may exceed specifications, but instrument will recover to within rated accuracy.

AC VOLTS (mean sensing, RMS Calibrated)

Range	Zin	Input Protection Limit
100 MV	1 Megohm	250 V rms
1 V		250 V rms
10 V		500 V rms
100 V		500 V rms
1000 (500 V, max.)		500 V rms

Accuracy . . . . . 0.2% rdg ±.05% FS, 60 Hz to 10K Hz all ranges
0.25% rdg ±.05% FS to 40 Hz
0.5% rdg ±.15% FS to 20K Hz

Overrange Capability . . . . . 100% (to 19999) on all ranges except the 1000 V range where the maximum allowed is 500 V AC.

Resolution . . . . . 10 microvolts

Full Scale Step Response . . . . Three seconds, maximum, (to within 0.2% of final value)

DC AMPS

Range	Voltage Drop (nom.)	Accuracy
100 µA	0.1 Volt	±0.15% rdg ±1 digit
1 mA	0.1 Volt	±0.15% rdg ±1 digit
10 mA	0.1 Volt	±0.15% rdg ±1 digit
100 mA	0.1 Volt	±0.15% rdg ±1 digit
1 A	0.1 Volt	±0.20% rdg ±1 digit

Overrange Capability . . . . . 100% (to 19999) on all ranges

Input Protection Limit . . . . . 3 Amps, any range, by fuse and clamp diodes

Resolution . . . . . 10 nA

Full Scale Step Response (to within 0.05% of final value) . . . . 0.5 sec.

AC AMPS (40Hz to 10K Hz)

Range	Voltage Drop (nom.)	Rated Accuracy
100 µA	0.1 Volt	0.35% rdg ±0.05% FS
1 mA	0.1 Volt	0.35% rdg ±0.05% FS
10 mA	0.1 Volt	0.35% rdg ±0.05% FS
100 mA	0.1 Volt	0.35% rdg ±0.05% FS
1 A	0.1 Volt	0.4% rdg ±0.05% FS

Overrange Capability . . . . . 100% (to 19999)

Input Protection Limit . . . . . 3A (by fuse and clamp diodes)

Resolution . . . . . 10 nA

Full Scale Response . . . . . three seconds maximum

INSTALLATION

GENERAL

Inspect the instrument for possible damage in shipment. If damage is noted, notify the carrier and supplier before using the instrument.

CARRYING HANDLES

Remove the carrying handles and knobs from the accessory container. Mount handles to the case as shown in Figure 2. The knobs differ at their threaded ends and may be used on either side of the case. When oriented for carrying, both handles should be rotated to the front of the case, at which point their detents will lock and may be secured by tightening the knobs.

JUMPER CONNECTOR

A twenty terminal jumper connector has been provided in the accessory kit. Mount it on the card edge connector at the rear of the instrument near the lower edge. Observe orientation markings, and secure in place with its captive screw.

TILT-STAND OPERATION

For bench or table top use, the handles should be locked in the open position shown in Figure 2. Two stable orientations of the handles are possible, each providing a different height off the table. In one position the inner handle is forward; in the second, it is to the rear.

It is important that the detents on the handles be engaged when in the tilt-stand position in order to provide maximum stability.

PANEL MOUNTING (The instructions in the following section should be followed only for panel mounting. For bench top operation, skip to page 10 .)

The Model 1242 has been provided with an option for mounting on a 1/8 inch panel. Special mounting screws have been provided in the accessory kit and the panel cut-out dimensions are given in Figure 3.

In mounting the instrument on a prepared panel, the circuit board inside the case must be repositioned forward by 1/8 inch. To perform this modification without damage to the instrument, the following instructions should be carefully followed. (See Figures 4 and 5.)

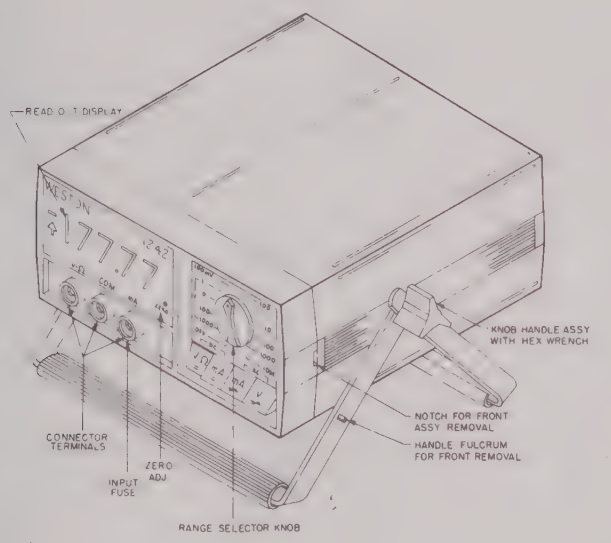


Figure 2. Handle/Stand Assembly

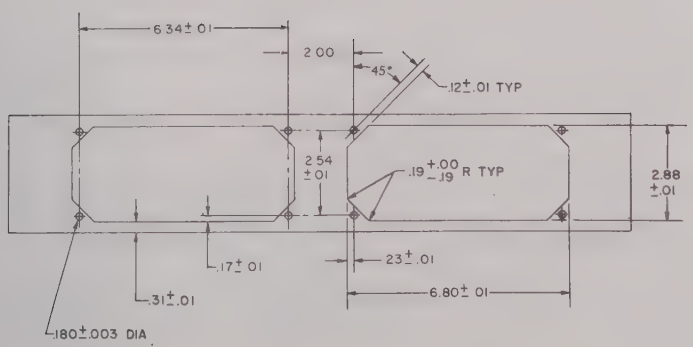


Figure 3. Panel Cut-Out Dimensions

CAUTION

Before proceeding, all push buttons must be in the "up" position and must remain up until modifications and mounting are completed. The buttons may be restored to the "up" position by depressing two buttons simultaneously.

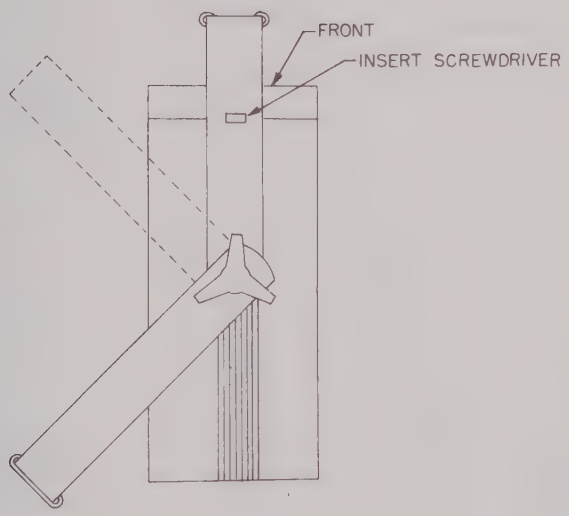


Figure 4. Removal of Front Assembly Using Handle/Stand as Fulcrum

a. Stand case on back end with inner handle locked in the front position as shown in Figure 4.

b. The front may now be removed. Starting on one side, insert a screwdriver blade, about 1/8 inch, extended through the rectangular hole provided in the inner handle, and into the notch provided in the front assembly. Using the handle as a fulcrum, gently pry the front upwards. It will snap into a new position, 1/8 inch forward. Repeat on the other side. Now reset the screwdriver blade 1/16 inch lower on the front so as to engage the edge of the front assembly, and pry up the front one more notch on each side. The front will now come free.

c. Before pulling off the front, swing the handle clear of the front and reset in the table top position.

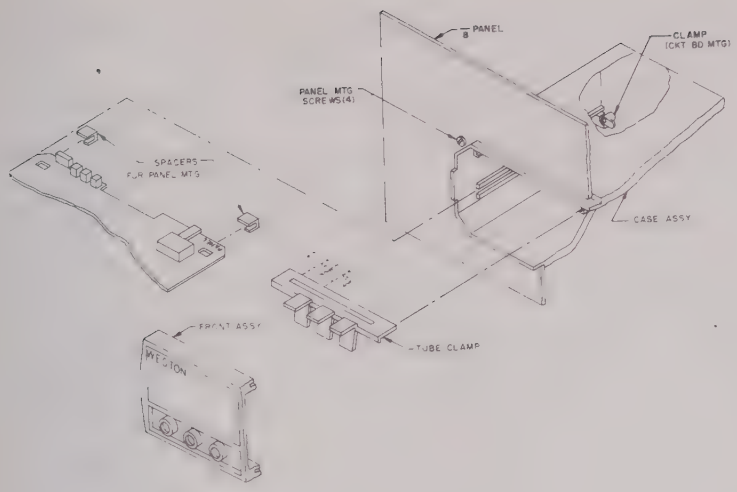


Figure 5. Panel Mounting (optional)

d. Facing the instrument's front, gently pull the front forward, maintaining care that the switch contacts behind the push buttons are not damaged. The switch shaft may come out with the front. Lay the front down on the table.

e. Remove the shaft from the front and replace it in the rotary switch assembly.

f. The leads may now be removed from the front and the front put aside temporarily. Note the interconnections so as to reconnect correctly. (See Figure 23).

g. The handles may now be removed.

h. To remove the circuit board, rotate the two screws at the rear of the case 1/2 turn counterclockwise. This will rotate two clamps freeing the board from the case. (See Figure 5.) Remove the edge connector guard at this time.

i. Grasp the circuit board from the front of the case and remove. This can be assisted by pushing on the rear of the circuit board at the edge of the accessory connector.

j. The board must be advanced 1/8 inch forward in the case to allow for panel mounting clearance. One eighth inch spacers have been provided on the tube clamp. Remove the tube clamp and break off the L-shaped spacers at its rear edge. (See Figure 5.) Trim spacer edge with razor blade.

k. Slip the spacers onto the rear of the circuit board behind the rectangular cutouts in the space marked PANEL. The spacers should be oriented with the cut-out side down. Secure them in place with a small amount of cement such as plio-bond. When properly positioned, none of the word "Panel" will be visible.

l. The circuit board mounting clamps must now be advanced by 1/8 inch to engage the new position of the cutout. Rotate the clamp screws at the rear counterclockwise about 6 turns until both clamps can be rotated past the stops built into the case.

m. Insert the circuit board into the case making sure that the clamps can slide into the cutouts on the circuit board in this new position.

n. Slide out the circuit board one-third of its length and reinsert the tube clamp in back of the display tubes and into the slides provided within the case.

o. Slide the circuit board all the way back into the case and secure by rotating the screw clamps.

p. The case may now be mounted into the prepared panel by means of the screws and inserts provided at the front of the case.

q. The leads may now be connected to the front assembly. Be cautious that the switch contacts are not damaged in the process.

r. The front panel may now be reinstalled on the case. Observe that all buttons are up and that the notch in the range knob lines up with the spline on the switch shaft.

BATTERY PACK OPTION

Instructions for mounting the battery pack accessory are provided with the battery pack. Interconnection will be made through the accessory connector at the rear of the case. When operated with a battery pack, the accessory will mate with a cable-connector assembly provided on the battery pack.

The jumper connector should be stored for safe-keeping during this mode of operation, and should be replaced on the card edge connector when reverting to line-only operation.

POWER REQUIREMENTS

The Weston Model 1242 has been designed to operate on 115 VAC or 230 VAC, 50 Hz to 400 Hz. A rear panel switch permits operation in either mode. Be sure that the switch is in the proper position for the local power lines before applying power. If 115 VAC is applied in the 230 volt position, only a faint display will occur. If 230 VAC is applied in the 115 VAC position, a rear panel fuse will blow out. The line voltage ratings of this instrument will permit it to extend to 15% above or 10% below nominal line voltage.

The Model 1242 is equipped with a three conductor power cable that grounds the instrument when plugged into a suitable outlet. To preserve this feature when operating with a two contact outlet, use an adapter and connect the pig-tail on the adapter to a suitable ground. (See Figure 8, rear panel description for further details.)

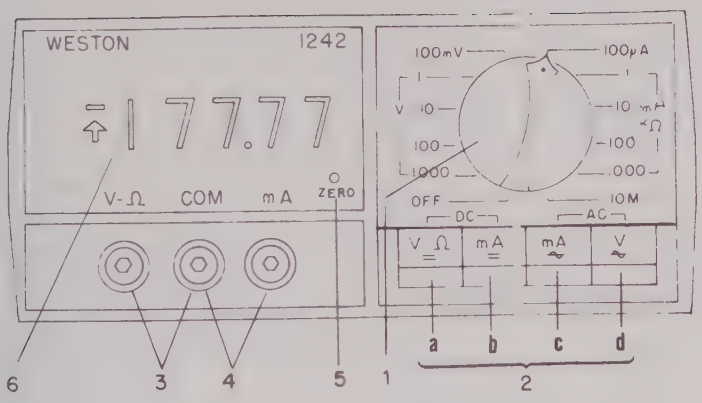


Figure 6. Front Panel Description

OPERATION

1. Range Switch

   a. Applies AC power to instrument. ON is any position but OFF.

   b. Permits range selection for AC or DC Voltage or Current when switched to V-mA, in conjunction with push button function switch.

   c. Permits ohms range selection when switch to ohms positions, in conjunction with V-Ω push button switch.

2. Function Push Button Switches

   a. Permits, in conjunction with range switch, the measurement of DC volts or ohms.

   b. Permits, in conjunction with range switch, the measurement of DC current.

   c. Permits, in conjunction with range switch, the measurement of AC current.

   d. Permits, in conjunction with range switch, the measurement of AC volts.

3. Input V-Ω jack (left) and COM jack (center) are inputs for AC and DC volts and ohms.

4. Input mA jack (right) and COM jack (center) are inputs for AC and DC current.

5. Zero adjustment.

6. Display

a. Three cold cathode numeral tubes with internal decimal points. Decimal point is automatically determined by the range switch.

b. An overrange digit to carry ten-thousands digits information. This will either indicates "1" or not at all.

c. A "-" polarity indicator to automatically indicate polarity of input for DC volts and milliamperes; it reads "-" for negative DC measurements and remains inactive for AC measurements, ohms and positive DC.

d. An outrange lamp, in the shape of an arrow, indicates an input beyond 19999, in which region the display is locked at 0000. This instructs the operator to shift to a higher range setting.

INPUT OVERLOAD PROTECTION

All input circuits are protected against input overload by generous margins as given under "Specifications". The voltmeter input circuit uses resistive dissipation in conjunction with diode connected transistors to limit the voltage to the input amplifier. The "ohms" circuit also uses resistive dissipation. The "current" circuit protects its shunts by a diode network and the diodes by a fuse. The current circuit fuse, 3 Amp 8AG, is located behind the mA input jack. It is removable with a wrench built into one of the knob handles.

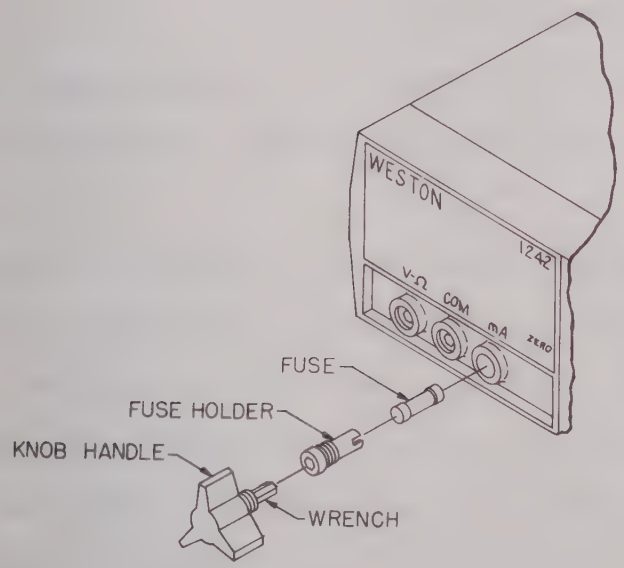


Figure 7. Input Fuse Replacement

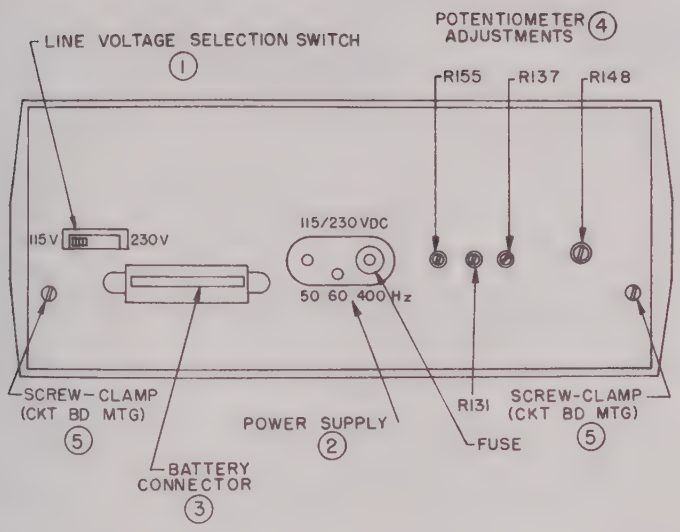


Figure 8. Rear Panel Description

1. Line voltage selector is a two position slide switch. Left position is for 115 volt power line operation. Right position is for 230 volt power line operation,
2. AC Power line connector is a three pin recessed male connector. The right hand pin supports a 1/4 amp. 8AG fuse. It is removed with the aid of the small wrench designed into the tip of one of the tilt-stand knobs.
3. A card edge connector is provided to accommodate the accessory battery pack. When used without the battery pack, the jumper connector provided in the accessory kit should be installed on the card edge connector and secured in place with the captive screw.
4. Four adjustments (ohms calibration, +V, -V, 20MΩ) are provided for periodic standardization. See Maintenance Section.
5. Screw-clamps used for securing circuit board.

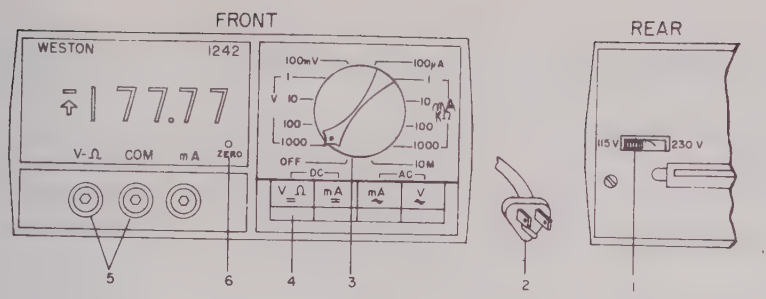


Figure 9. DC Voltage Measurement

1. Set line voltage selector switch on rear panel to proper line voltage position, and check that the jumper plug is on rear card-edge connector.
2. Plug instrument power cord into AC power outlet.
3. Set range switch to 1000.
4. Depress the function push button DC (V-Ω) to the down position.
5. Allow 15 minutes warm-up time for stabilization to insure best accuracy.
6. Connect test leads to the jacks marked V-Ω and COM.
7. Short test leads and set range switch to 100 mV. The display should read zero (00.00). If not, rotate the zero control to achieve this.

NOTE

If the input leads are left open-circuited on the 100 mV or 1 volt ranges, the display reading will slowly increase due to the presence of a small current appearing across the high input impedance of the preamplifier. a similar effect occurs on any range if all the push buttons are up. On the 10, 100, and 1000 volt ranges, the reading will remain at zero.

8. Set instrument to the 1000V range, apply input and observe the reading. If the readout exceeds 1000V remove the input immediately as an overload condition exists. Otherwise, reduce range switch setting until the proper range is reached. Table below indicates proper readout limits for each range.

Range	Proper Readout Limits
100 mV	00.00 - 199.99
1 V	.1999 - 1.9999
10 V	1.999 - 19.999
100 V	19.99 - 199.99
1000 V*	199.9 - 1000

* Note that while all lower ranges have a 100% overrange capability, the 1000V range is limited by breakdown consideration to 1000V.

CAUTION

Do not float the meter more than 500V above ground or damage to the instrument may result.

While the Model 1242 will perform to specification below 2000 digits, best performance will be obtained by readjusting to a more sensitive range when the reading goes below the limits shown.

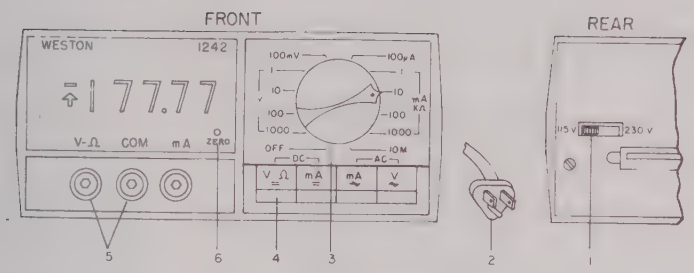


Figure 10. Ohms Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position, and check that the jumper plug is on rear card-edge connector.
2. Plug instrument power cord into AC power outlet.
3. Set range switch to 100 MV.
4. Depress the function push button DC (V-Ω) to the down position.
5. Connect test leads to the input jacks marked V-Ω and COM. Allow 15 minutes to warm-up for stabilization to insure best accuracy.
6. Short test leads. The display should read zero (00.00).

   If not, rotate the zero control to achieve this.

NOTE

When using the 1 Kilohm range, the reading with shorted input test leads may differ from that on other ohmic ranges. A small residue of less than one ohm may be indicated due to lead resistance. The user has the option of either subtracting this residue from his measurement of the unknown or nulling the lead resistance out by adjustment of the zero control. If the latter option is taken, the meter must be re-zeroed when returning to other ohmic ranges or modes of operation.

7. Connect test leads to the unknown resistance and observe reading.

Increase or decrease range setting until proper range is reached.

Table below indicates proper readout limits for each range.

Range	Proper Readout Limits
1K	.0000 - 1.9999
10K	1.999 - 19.999
100K	19.99 - 199.99
1M	.1999 - 1.9999
10M	1.999 - 19.999

CAUTION (for 1K, 10K ranges)

The resistance measurement circuitry is protected up to 230* volts rms or DC against the application of excessive voltage, by the power dissipation of internal components. Application of higher voltages than this may damage the instrument. Short term errors may be noted in the resistance readings after overload, but accuracy will eventually recover to within specification.

* 230 volts for 30 seconds, max.

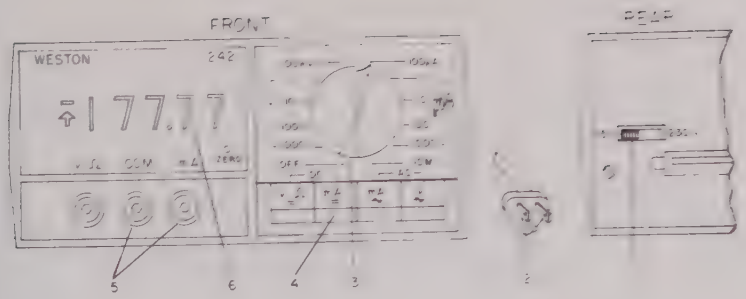


Figure 11. DC Current Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position, and check that the jumper plug is on rear card-edge connector.
2. Plug instrument power cord into power outlet.
3. Set power/range switch to 1 ampere or the desired lower range if known.
4. Depress the function push button DC-mA to the down position. Display should read zero. If not, rotate the zero control to achieve this.
5. Using the test leads, connect the unknown DC current into input jacks mA and COM.
6. Observe reading: Decrease range switch setting until the proper range is reached.

Range	Proper Readout Limits
100 µA DC	00.00 - 199.99
1 mA DC	.1999 - 1.9999
10 mA DC	1.999 - 19.999
100 mA DC	19.99 - 199.99
1000 mA DC	.1999 - 1.9999

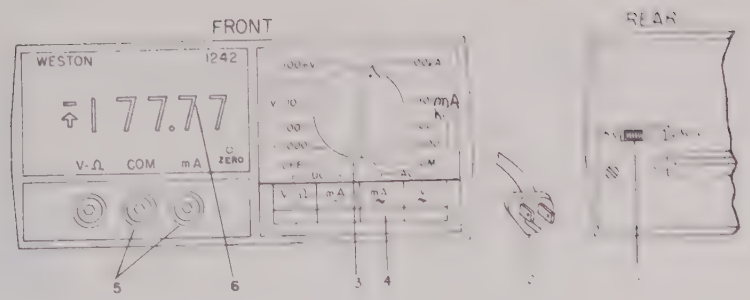


Figure 12. AC Current Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position, and check that the jumper plug is on the rear card-edge connector.
2. Plug instrument power cord in AC power outlet.
3. Set range switch to 100 MV.
4. Depress the function push button DC (V-Ω) to the down position.
5. Connect test leads to the input jacks marked V-Ω and COM. Allow 15 minutes to warm-up for stabilization to insure best accuracy.
6. Short test leads. The display should read zero (00.00). If not, rotate the zero control to achieve this.
7. Set range switch to 1000 mA or to the desired lower range if known.
8. Depress the function push button AC-mA to the down position.
9. Connect the unknown AC current into input jacks mA and COM.
10. Observe reading: decrease range switch until proper range is reached.

Range:	Proper Readout Limits
100 µA AC	00.00 - 199.99
1 mA AC	.1999 - 1.9999
10 mA AC	1.999 - 19.999
100 mA AC	19.99 - 199.99
1000 mA AC	.1999 - 1.9999

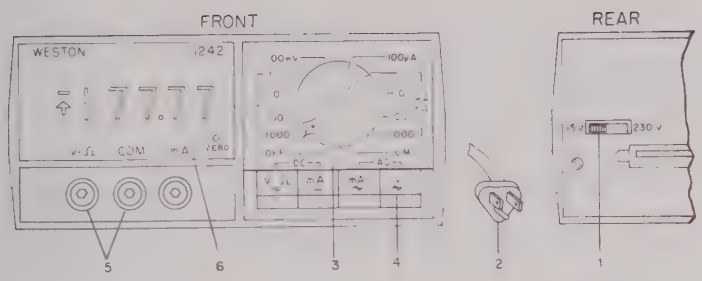


Figure 13. AC Voltage Measurement

1. Set line voltage selector switch, on rear panel, to proper line voltage position.
2. Plug in power cord to instrument and the AC power outlet.
3. Set range switch to 100 MV.
4. Depress the function push button DC (V-Ω) to the down position.
5. Connect test leads to the input jacks marked V-Ω and COM. Allow 15 minutes to warm-up for stabilization to insure best accuracy.
6. Short test leads. The display should read zero (00.00). If not, rotate the zero control to achieve this.
7. Set power/range switch to 1000 or the desired lower range if known.

CAUTION

500 volts is the maximum AC voltage allowable in the 1000V position.

8. Depress the function push button AC-V to the down position.
9. Observe readings. Decrease range switch until proper range is reached.

Range	Proper Readout Limits
100 mV AC	00.00 - 199.99
1 V AC	.1999 - 1.9999
10 V AC	1.999 - 19.999
100 V AC	19.99 - 199.99
500 V AC *	1999 - 500.00

NOTE: When measuring AC voltage or currents, distorted sine waves can be a source of error. This instrument will indicate within rated accuracy only on pure sine waves. Typical 3rd harmonic distrotion levels can introduce errors as much as 1/3 of the percentage of 3rd harmonic distortion present.

* This range is limited to 1/2 of nominal full scale because of breakdown consideration.

THEORY OF OPERATION

INTRODUCTION

This section presents the design and operating principles of the Weston 1242 Digital Multimeter. The theory of operation is presented at the functional level in the section immediately below and in greater detail on the pages following. Complete schematic diagrams are included for reference in the Maintenance Section.

Model 1242 incorporated all circuitry needed to make measurements of DC voltage and current, AC voltage and current, and resistance.

The basic measuring circuit is a bipolar analog to digital converter operating on the dual-slope principle. It has a measurement range of ±4 volts DC. All inputs are converted to DC volts and amplified or attenuated for measurement by this circuit.

Resistance is measured by passing a scaled constant current through the unknown and measuring the DC voltage across it. Maximum current never exceeds 100μA.

Alternating voltages are converted to DC by an average sensing, RMS calibrated converter assembly. Full scale output voltage for all ranges is 1 volt DC.

Current is measured by the voltage drop it establishes across a ring shunt network. If DC, it is measured directly. If AC, it is applied to the AC converter first. Full scale shunt voltage is 100 millivolts for all ranges.

The DC voltmeter section and the several conversion circuits are interconnected by a complex of function switches and rotary range switches which make possible decimal point switching, input ranging, gain changes in the preamplifier and shared usage of the precision attenuator. Rather than present

the complete system diagram in the test, with all of its switching complexity, we have elected to present the functional modes, one sub-circuit at a time, indicating the required signal interfaces. Interconnection information is presented in the master schematic diagrams in the maintenance section and the interested user will be better equipped to follow it after first digesting the operating theory of the functional parts.

We have started with the A/D converter, that circuit being basic to all other modes. Then the front-end analog circuitry including attenuator, amplification and switching which complete the DC voltmeter circuit. Resistance, current, AC converter, and power supply follow in that order.

The following sections will present the theory of operation of the A/D converter.

CIRCUIT DESCRIPTION

DC VOLTMETER CIRCUIT

Common to all measuring functions is a dual slope, bipolar A/D converter. The operating voltage is ±4 volts full scale for 10,000 digits with a 100% overrange capability. All measurands are scaled to ±4 volts by a preamplifier and suitable attenuators, shunts, or converters. The display has a maximum reading of 19999 suitable accompanied by decimal points, polarity sign and an outrange display.

The circuit operation will be explained with the aid of Waveforms Figure 14 and the Block Diagram Figure 15.

DUAL SLOPE A/D CONVERSION

Dual slope is an integrating method of A/D conversion which, in common with all integrating methods, reduces the affect of power-frequency interference on the input or appearing as power supply ripple. Integrating time in the Model 1242 is 100 MS, providing excellent rejection of 50 Hz, 60 Hz, 400 Hz and any other components whose periods are integral sub-multiples of 100 MS.

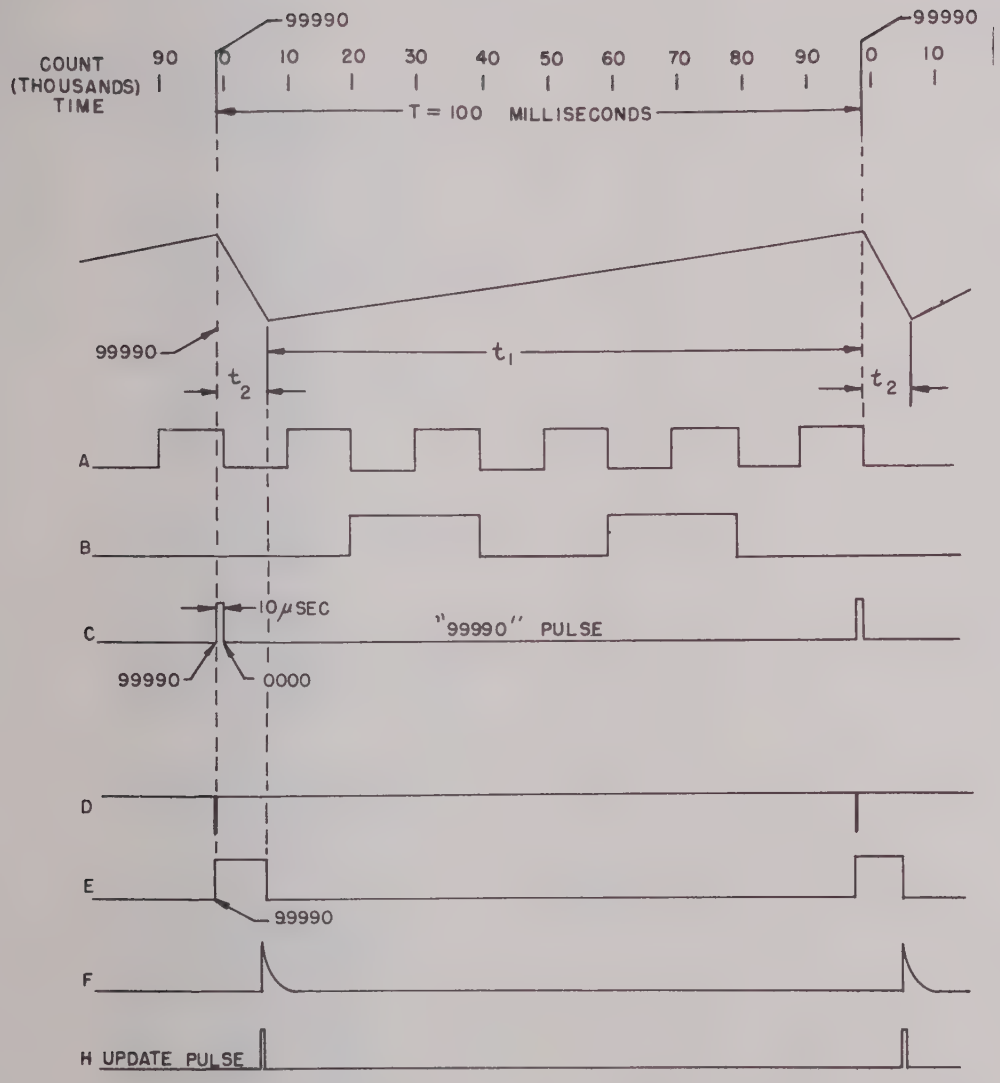
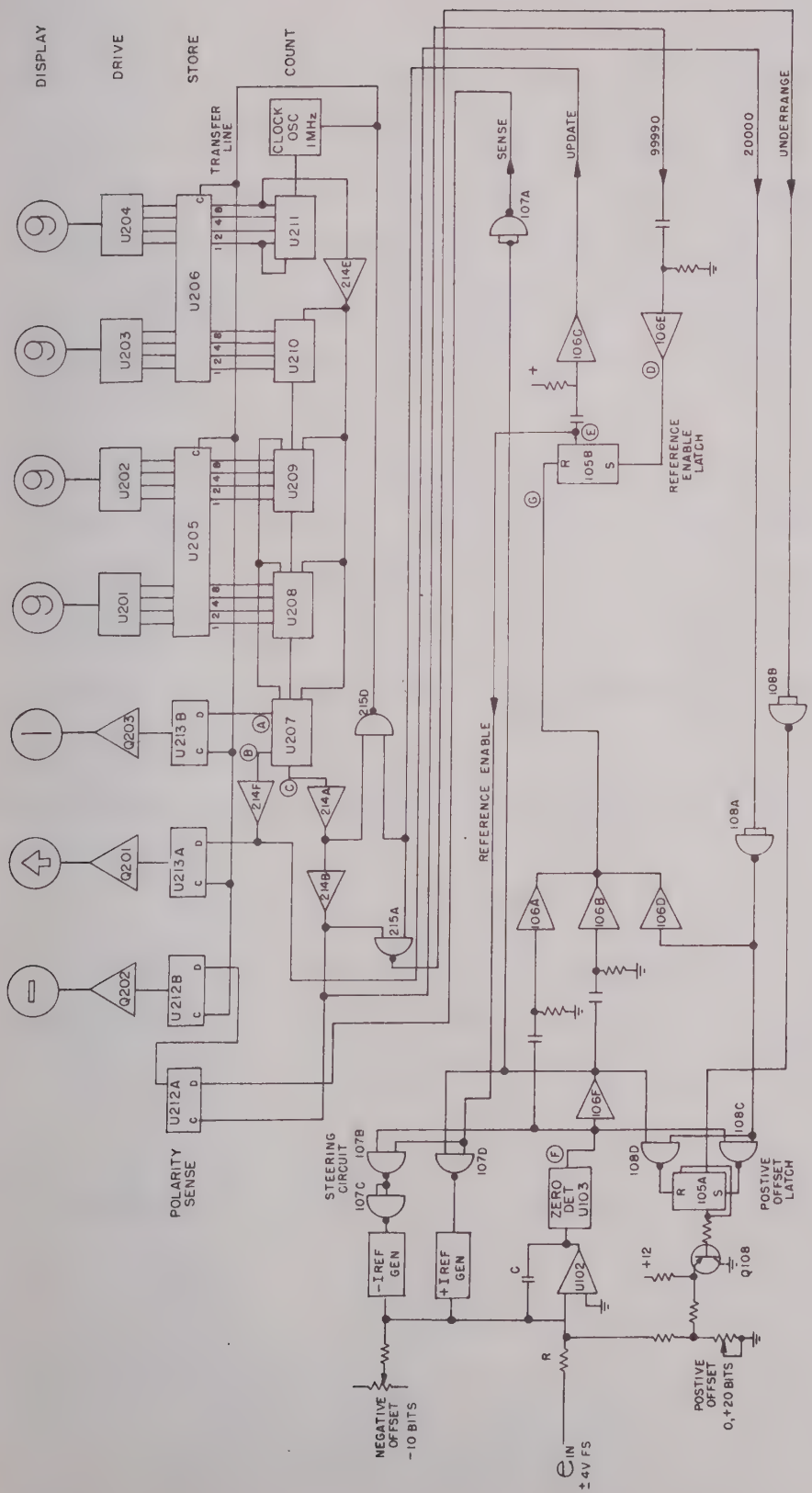


Figure 14. A/D Converter Waveforms



Figue 15. Block Diagram

The dual slope feature provides an added, unique advantage, not common to other integrating methods. In older systems, amplitude is converted into a time interval, which is digitized by counting the number of clock pulses in that interval. Conversion accuracy is directly dependent on clock accuracy, on the stability of an RC timing network, and of a voltage reference. Dual slope, by contrast, converts amplitude into a ratio of two time intervals, both proportional to clock period and hence independent of clock accuracy. Only a stable voltage or current reference and stable resistor, both easily attainable, are required.

Figure 14 shows the integrator waveform responsible for this conversion. Integrating cycle time is constant at 100 milliseconds, corresponding to 100,000 pulses from the 1 MHzclock oscillator. The cycle is divided into two intervals; ramp up t_1, and ramp down, t_2. The waveform shown corresponds to a negative DC input, for which the integrator will ramp in the positive direction. Positive inputs create a negative ramp.

During t_1, the integrator ramps up from zero under the influence of Ein, R, and C such that

$$e_{max} = \frac{Ein}{R} \times \frac{t_1}{C} \text{ volts}$$

Interval t_1 is terminated when the counter state reaches 99990, at which point I_{REF} is injected. The sense of I_{REF} is opposite to that of Ein and its magnitude is always larger than Ein/R so that the integrator now discharges at a rate

$$\frac{1}{C} \left(I_{REF} - \frac{Ein}{R}\right) \text{ volts/sec}$$

Interval t_2 will terminate at zero crossing such that

$$\frac{Ein\ t_1}{RC} = \left(I_{REF} - \frac{Ein}{R}\right) \frac{t_2}{C}$$

Since $t_1 + t_2 = T$, solving for t_2 yields $t_2 = \frac{EinT}{I_{REF}\ R}$

Further, since T contains 100,000 pulses, we can express t_2 and T in terms of numbers of pulses, as

$$N = \frac{100{,}000\ Ein}{I_{REF}\ R}$$

Therefore N is a quantity which is independent of both clock frequency and capacity C. If interval t_2 were to start at 100,000 (equivalent to zero) instead of 99990, the transfer command generated at the end of t_2 would then transfer the number N into display storage, presenting a readout proportional to Ein. For reasons to be detailed later, the start of t_2 is advanced 10 clock pulses and an offset voltage equivalent to 10 microseconds is injected so that in the absence of Ein the display will read zero.

The conversion process repeats with a new conversion every 100 milliseconds. If the new count is the same as the previous one, the number in storage will not change, and no flicker will result.

The points to remember in reading what follows is that the key events in each cycle are the count 99990 which initiates t_2 by introducing a reference current, and the crossing of zero by the integrator, which terminates t_2 and commands a readout into storage.

For reference purposes, the full scale input voltage to the integrator is ±4 volts, and input resistor R is 40 Kilohms, providing a full scale input current of 100 microamperes (for 10,000 digits). The sensitivity of the converter is thus 400 μ volts/digit or 10 nanoamperes per digit.

A/D CONVERTER - DETAILED CIRCUIT DESCRIPTION (Figure 15)

The analog to digital converter and the 20,000 bit display it generates is under the control of a 100,000 bit timing sequence, driven by a 1 MHz clock oscillator. The 1 MHz clock drives a 100,000 bit counter chain consisting of five decade counters U207 through U211. Counters U208, U209, U210 and U211 accumulate counts up to 9999 and drive two 8 bit storage registers U 205 and U206.

Counter U207 registers the "10,000" count and provides outrange sensing and control functions. Waveforms derived from U207 are shown at A,B, and C of Figure 14.

Synchronization

Interval t_2 is synchronized by pulse waveform C, a 10 μ sec wide pulse (also referred to as the 99990 pulse) which occurs only once in each 100,000 clock pulses. Its leading edge is shaped by an RC network and inverter 106E to provide a negative pulse D, setting the Reference Enable Latch 105B. The Reference Enable Latch occupies a central position in the operation of the converter. When set, producing a positive transition at E, it permits a reference current to be injected into the integrator, starting interval t_2.

Polarity Sensing

Simultaneously, the positive transition of C triggers polarity sensing Flip-flop U212A, causing it to take a state determined by the polarity of the input signal at that time. Polarity is determined by the state of comparator U103, as transmitted by 106F and 107A. For the present example, a negative input causes a positive ramp. Therefore, at the onset of t_2, the ramp is at its greatest positive value, and the sense line is low since U103, 106F, and 107A invert. Consequently U212A is set to zero. When this state is transferred to U212B at the end of t_2, the "-" lamp is enabled.

Reference Current Control

During t_2, the "1" state of the Reference Enable Latch (105B) enables gates 107B and 107D, permitting one of the reference current generators to inject 1 ma into the summing junction. The choice of reference current polarity is made by logic gates 107B, C, and D under control of the steering inputs provided by comparator U103 and inverter 106F. Since input signal polarity is negative in this example, a positive current is injected into the summing junction of U102 forcing the integrator back to zero.

Zero Crossing

Interval t_2 ends when the integrator output reaches zero. In so doing, the output of zero-detector U103 undergoes an abrupt positive transition, (F). The resulting waveform is shaped into a negative trigger pulse at (G). (If the input voltage had been positive, a negative transition at "F" would have been similarily shaped after inversion by 106F. Therefore, any zero crossing is converted into a negative trigger pulse.) The trigger pulse is applied to reset Reference Enable Latch 105B, resulting in a return of waveform E to level zero. This transition initiates several actions as noted below.

Readout Command

First, the negative transition at E is shaped by an RC network and inverter 106C into a positive pulse 100 nsec wide, waveform H. This is inverted by 215D (unless inhibited under special conditions described below under "Offset") and commands the storage registers U205 and U206, to accept new count information from the decade counters. The count transferred at this time will be the number N developed during t_2. Time is thus made available by the width of H for ripple-through of carries which may have started just prior to zero crossing. Also, during the storage command pulse, the clock oscillator is momentarily inhibited, preventing any new pulses from entering the counter. At the termination of the transfer pulse, the storage registers are locked up at their new condition and the display tubes they drive remain fixed in display.

The positive going trailing edge of the transfer pulse activates three more functions. It transfers the state of the waveform A (which goes high at the count of 10,000) into storage flip-flop U213B, and that of waveform B(which goes high at 20,000) into the outrange storage flip-flop U213A. It also transfers polarity information from polarity-sensing latch U212A into polarity-storage flip-flop U212B.

Offset

It will be recalled that the start of t_2 is offset in time by 10 clock pulses to a count of 99990, and that an analog offset voltage equivalent to 10 digits (0.1% of full scale) must be introduced into the integrator to make the display read zero when Ein = 0. The reason for this offset and the mechanism by which it is accomplished will now be presented.

During t_1 and in the absence of any injected offset, the integrator would ramp up completely under control of Ein. If Ein were very small the slope would be correspondingly small. During t_2, the reference current reverses this slope sharply, crossing zero and driving the zero-crossing comparator to its opposite state. Ideally, the crossing of zero would immediately terminate the reference current and result in a reversal of the ramp and an immediate return of the comparator to its initial state. Practically, however, inevitable time delays and finite comparator gain, result in an overshoot during t_2. When the reference current is terminated, the small ramp slope due to small values of Ein could prevent the comparator from being immediately reset. In particular, if the slope were small enough, the comparator would not be reset before the next synch pulse (99990) occurs. In that event, the wrong reference current will be injected and an oscillatory mode of behavior will take place in which the display will alternate between excessively low and excessively high readings. To prevent this, an offset is permanently injected, so that even when Ein = 0, the ramp up slope will be large enough to permit comparator recovery during one 100 ms frame. Ten digits worth of offset are injected (100 nA) and the logic is offset from zero to 99990 to compensate.

The polarity of the offset must be the same as the polarity of the input signal. To achieve this, two offset sources, one fixed and one digitally controlled, are provided. The first, a negative offset provides a net 10 bit negative input current to the summing junction of the integrator, including compensation for intrinsic offset in the integrator operational amplifier. The second is a 20 digit positive offset which can be switched on or off. The two provide a choice between +10 (+20-10) and -10 (0-10) digits.

The +20 digit offset is under control of switch Q108 and offset latch U105A, and operates as follows. At the digital count of 20,000 (chosen for convenience), gates 108C and 108D are enabled and the state of the zero comparator is used to steer a set or reset pulse to latch 105A. If input Ein is positive, this will be reflected in the state of the comparator and the latch set so that Q108 is turned off and the +20 digit offset is turned on. For negative inputs the reverse is true. When Ein is large, there is no ambiguity or oscillatory behavior.

If Ein were to drop from some large positive value to some small negative value (e.g. -5 digits), then the count available at zero crossing would be 99995, rather than -5. Logic has been provided to inhibit transfer of count into storage under this condition. Waveform C will be high during "99990-100,000", the output of 214A will be low, and the update pulse will be inhibited from passing through U215D. Further, the presence of an update pulse from 106C during the interval (99990 to 100,000) will create an underrange pulse (positive) at 215A which will be fed back to latch 105A, toggling it to its opposite state. The offset current will then reverse and the signal and offset will again be of the same polarity. Only one conversion period is lost during the changeover and the affect is not disturbing.

For further details of the logic and conversion circuitry, refer to the schematic diagrams at the rear of this manual.

DC VOLTMETER-ANALOG SECTION

The previous section described the operation of the A/D converter, with emphasis on the logic. This section will describe the analog circuitry, including the integrator and current sources, the preamplifier, and the various front-end converter circuits. For greater detail and specific component values, refer to Figure 25 , Schematic Analog Section, in the Maintenance portion of this manual.

Integrator

The basic integrator circuit, shown below, consists of an operational amplifier, connected in the inverting mode, and the logic-controlled current sources necessary for controlling ramp action, as described in the previous section.

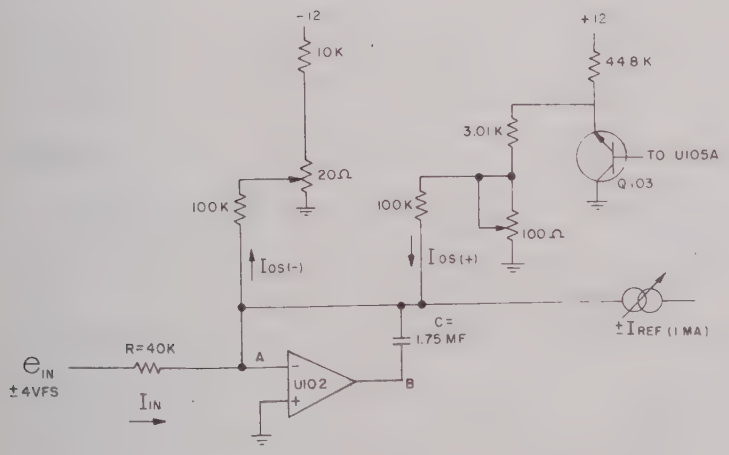


Figure 16. Integrator Circuit

Since the amplifier summing junction A is a virtual ground Iin = (4/40000)=100 μA full scale. During interval t_1, with no reference current, a negative 4 volt signal will draw 100 μA from the 1.75 MF capacitor forcing the integrator output B to ramp upwards linearly to support this current. When, at the count of 99990, a reference current of +1 ma is injected into the summing junction, the reference will supply the 100 μA and the remaining 900 μA will discharge the capacitor. B will then fall back towards zero at a rate 9 times as great as its rise and will take 10,000 clock pulses to reach zero. Other input voltages will give rise to corresponding fall times and displays. For example, an 8 volt input to the integrator would cause 200 μA to flow through R. A four-to-one time ratio would occur and the display count would be 20,000.

Integrator Offset Adjustment

Neglecting, for the moment, the 10 bit offset needed to insure stable readings near zero, there remains an inherent offset in the integrating amplifier, U102, which can account for up to ±5 digits of error. This must be zeroed out to prevent unpredictable ramping in the absence of a signal input. In addition, a switchable offset of ±10 counts must be provided for zero region stability. The negative offset supply shown in Figure 16, provides a permanent offset of -10 digits beyond that needed for the ±5 inherent in the amplifier. It does this by possessing a range of from -5 to -15, with some margin to spare for component tolerances.

The positive offset supply is set for +20 digits under logic control which can change it from +20 to zero.

The net offset will thus be either +10 (+20 -10) or -10 (-10 +0). Since the injected offset is only 10 digits, an inaccuracy or drift of this value by one or two percent will be inconsequential and these circuits are therefore not regulated beyond that which the power supply provides.

Reference Current Circuits (Figure 17)

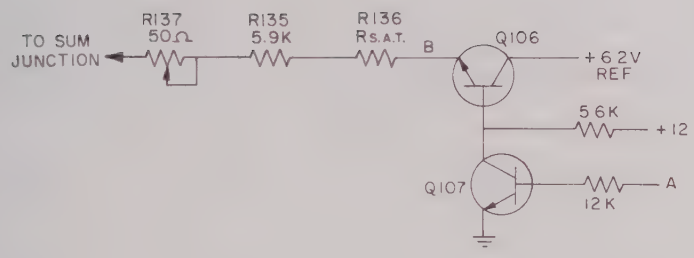


Figure 17. Current Source

The reference current circuit consists of a stable 6.2 volt reference, a low offset transistor switch and stable scaling resistors, and is illustrated in Figure 17 for the case of a positive reference (used with negative inputs).

Q106 is the series switch, operated in the reverse alpha mode. Q107 is the control transistor which permits Q106 to close when point A goes to zero. Under this condition, the Q106 is biased on and the 6.2 volts appears (with negligible transistor drop) at the emitter. Since the summing junction is a virtual ground, the current which flows is determined by V_{REF} and the total resistance, which can be adjusted for full scale calibration. In order to achieve settability to one part in 20,000 during calibration, the resolution of the resistance network would have to be .005% of 6200 ohms or about 0.3 ohms. Practically achieveable pot resolutions place the pot requirement at 50 ohms. However, a span of 50 ohms in 6.2K is less than 1% making it impossible to accommodate economically achievable zener diode tolerances.

A selectable Resistor R136 provides a coarse trim to span a 3% tolerance range for the diode. It is a customized 5 terminal network with jumper leads and is programmed during calibration in 37 ohm increments.

Voltmeter Input Circuitry

It has been pointed out that the integrator operates at ±4 volts full scale. This level which amounts to 400 microvolts per digit renders the A/D converter relatively insensitive to offset voltage variations (due to time and temperature) in the integrator. To achieve this level on all input ranges, requires both attenuation and gain. These two functions are shown in Figure 18.

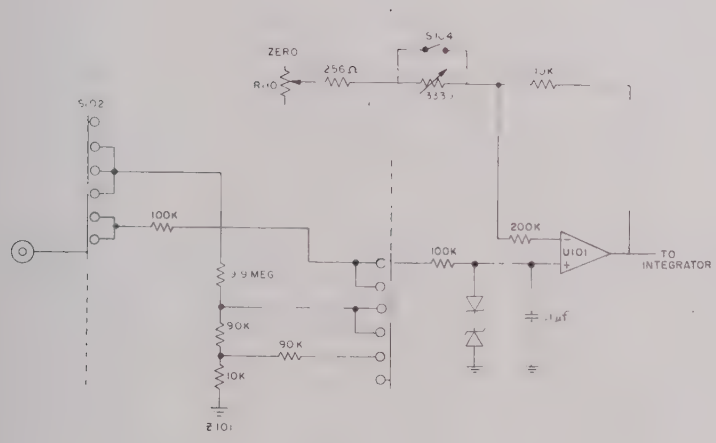


Figure 18. Voltmeter Input Circuit

U101 is a non-inverting amplifier with a gain of either 4 or 40. The non-inverting connection guarantees very high input impedance so that attenuator Z101 is not affected by loading changes as the range is changed. The input circuitry of U101 is designed to provide very low input bias currents (2 nA max.) and very low offset voltage drifts with temperature (2 μV/°C max.).

These low values are essential to the stability of the instrument and U101 bears the principle burden of the instrument's quality.

On the 100 MV and 1 Volt ranges, the input is applied directly through two 100K buffering resistors which both guarantees a minimum balancing source resistance of 200K and absorbs energy due to overloads. The 10V, 100V, and 1000V ranges use a 10 megohm thin film attenuator with taps at 1/100 and 1/1000. The attenuator is padded to maintain a uniform 200K source resistance for the amplifier regardless of range settings, this balance being essential to minimize zero shifts with temperature, and range change.

This combination of attenuator and switch design, needed to maintain uniform source resistance, causes the amplifier U101 to alternately see 100 MV or 1 Volt full scale, (100 MV on the 100 MV and 10 volt range, 1 volt FS on the remainder). Therefore, the gain must be switched by 10 to 1 when changing ranges to maintain 4 V FS out. Gain switching is accomplished by S104, and the two gains are adjusted for an exact 10 to 1 ratio by an internal resistor adjustment (R114, R115, R117).

Finally, zener diodes (diode connected transistors) and an input capacitor are provided for input overload protection and supplementary input filtering, respectively.

OHMS CONVERSION

Resistance is converted to a DC voltage by means of a current source according to the table below. The currents are scaled to produce full scale voltages of +100 MV on the 1KΩ range and +1 volt on all other ranges.

Range	I_s	R scale	E FS
1 K	100 μA	10 K	100 mV
10 K	100 μA	10 K	1 V
100 K	10 μA	100 K	1 V
1 MΩ	1 μA	1 MΩ	1 V
10 MΩ	100 nA	10 MΩ	1 V

It will be noted that a voltage of 1 volt is maintained across the scaling resistor (I_s x R scale) on all ranges. This is accomplished by a boot-strapping technique as shown in Figure 19.

The voltage developed across Rx, E(Rx), is applied to the voltmeter input. Because both inputs of U101 are forced by feedback to assume the same potential, E(Rx) is also applied to the positive input of U104. A 1 mA current source applied to the negative input of U104 acts through R150 to add an additional 1 volt to E(Rx) at the output. Since the scaling resistor (R149 or part of Z101) is connected between U104 output and the V-Ω input terminal, the voltage across it will be maintained at 1 volt

The current through Rs is then determined only by Rs as shown in the table above. Assuming that negligible current is drawn by amplifier U101 (a practical assumption for most ranges), then the constant current will all flow through Rx creating the voltage to be measured.

Special design considerations which exist at the lower and higher ranges are as follows:

(a) 1 K,10 K range - These ranges require 10 K for a scaling resistor. While the 10 K could have been derived from a section of Z101 rather than as a separate component, the result would have been extreme vulnerability to burn out by misapplication of high voltage when in the 1 K or 10 K range position.

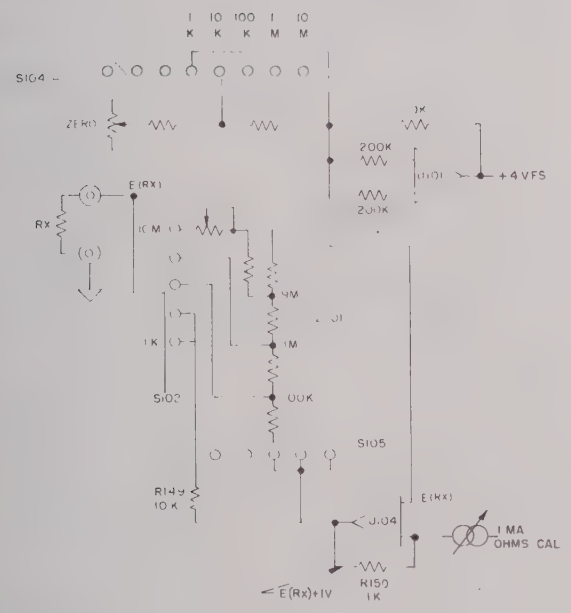


Figure 19. Ohms Conversion Circuit

Therefore, a precision power resistor was employed for these ranges.

(b) 10 MΩ range - On this range, the current source is 100 nA. Amplifier U101 can draw up to 2nA. Therefore, a 2% error can exist unless compensated. The 10 MΩ scaling resistor is reduced by tapping Z101 at 9 MΩ and adding an adjustable resistor (R147 and R148).

(c) 1 MΩ range - This range, operating on a 1 μA current source is susceptible to 2n bias current affects to the extent of 0.2%. This small error did not warrant a compensation control, but the scaling resistor tap on Z101 was reduced from 1 MΩ to 999 K to allow for an average value of bias current.

DC CURRENT CONVERSION

DC current is converted to a DC voltage by the network shown in Figure 20. Five 0.1% wirewound resistors are arranged in series, with taps, selectable by the range switch, at 0.1, 1, 10, 100, and 1000 ohms. The remaining circuitry is provided for overload protection only.

Current applied between the mA and COM jacks flows through the selected portion of the shunt network, developing a voltage between the selected tap and circuit ground. Since the total shunt resistance increases in decade steps as current range decreases, the full scale shunt voltage remains fixed at 100 millivolts for all ranges.

Accuracy is maintained on the highest current range by using a four-terminal Kelvin connection for the 0.1 ohm resistor. Thus, currents of up to 2 amperes are kept out of the potential circuit and cannot create added voltage drops in the intervening leads to appear as measurement errors.

The shunts are protected from damage due to excessive current by a combination of diode-clamps and fuse. The clamp circuit consists of two pairs of diodes, one for each polarity of overload. The S5A05 is a general purpose power diode permanently biased into conduction so as to back bias the low leakage S1594.

Since the voltage, even at 100% overrange, is 200 millivolts, the upper diode will normally be back-biased between 400 and 800 millivolts, a level sufficient to prevent excessive leakage, even for the 100 μA range. If a constant current sufficient to generate more than 1.2 volts is applied, the diodes will conduct and divert any larger currents away from the shunt resistors.

If the current should rise beyond 3 amperes, due to an excessive current source, or due to application of full line voltage, the fast response 3 amp fuse will blow and both shunts and diodes will be protected. The diodes have sufficiently high surge rating to withstand the momentary current pulse generated until the fuse disconnects.

All that has been said of DC current conversion applies equally to AC current conversion, except the routing of shunt voltage. In the case of AC currents, a voltage waveform of 100 mV RMS full scale is generated in the potential circuit. This waveform is converted to a DC voltage of 1 volt full scale by the AC Converter assembly. Interface between the shunt network and the operational rectifier in the AC Converter assembly is discussed more fully in the section below.

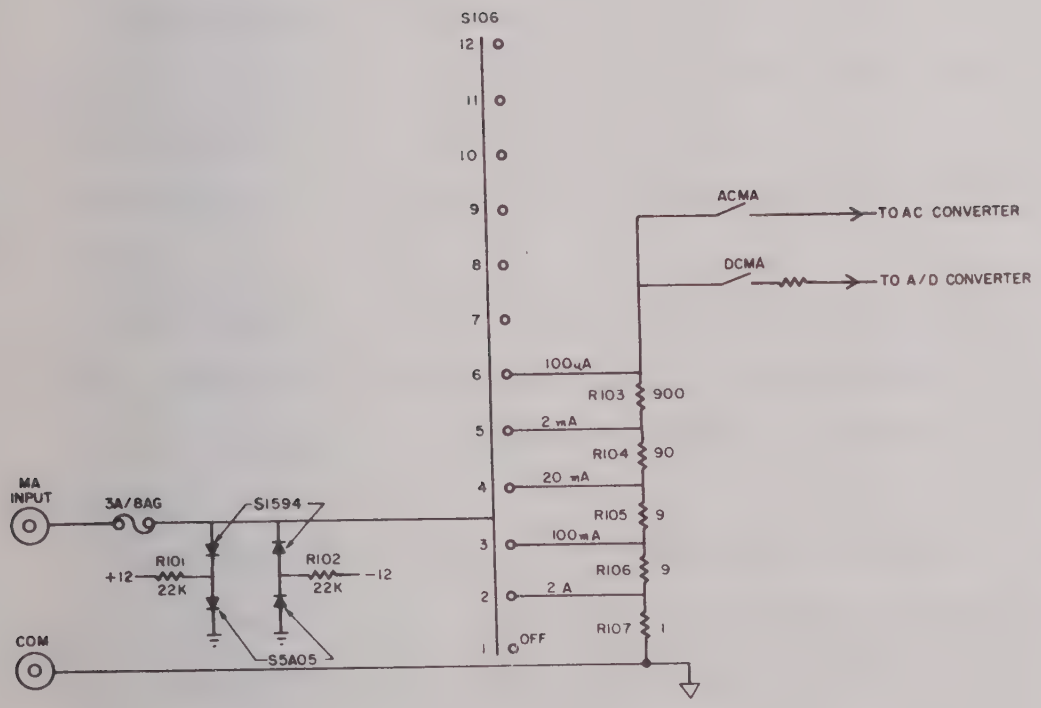


Figure 20. D.C. Current Converter Circuit

AC CONVERSION

The measurement of alternating voltages, whether due to AC voltage sources or current sources converted to voltage by shunts, is accomplished by an average sensing, RMS calibrated operational rectifier, supported by circuit elements which control ranging, frequency response adjustment and output ripple filtering. The circuit elements are shown in simplified form in Figure 21. Tracing signal flow from input leads through to the A/D converter, the following circuit functions are encountered:

1. Input Switches - These are push button switches which couple the AC converter to either the V-Ω input jack or the shunt chain depending on the measuring function. The ACV switch also protects the AC input coupling capacitor from high DC voltages which might be applied in the DCV mode.

2. Input Capacitor - blocks DC components riding on the input which might otherwise bias the buffer out of its proper operating range.

3. Input Attenuator - a 1 megohm resistor string with taps at 1/100 and 1/1000.

Signal levels of 100 mV or 1 V full scale bypass the input attenuator and are applied directly to the buffering circuit which drives the operational rectifier. Larger signals are attenuated to one of these two levels by action of S401.

4. Following the attenuator is a clamp network formed by two low-leakage, low capacitance diodes. The diodes protect the buffer and series resistors protect the diodes, in case destructive voltage levels are inadvertently applied.

5. A FET/bipolar follower circuit provides high input impedance and low output impedance at approximately unity gain.

6. Following the buffer, is the input network of the operational rectifier. Voltages of 100 mV or 1 V full scale are converted into input currents of 10 microamperes FS, RMS.

The input network switches in value from 10 K to 100 K under control of S402 to maintain the 10 microampere full scale level under all ranges.

Two capacitors are provided in shunt with the 90K and 10K input resistors to peak-compensate for roll-off introduced by stray capacity at the input of the buffer. In addition, two switchable roll-off networks, from the resistor junction to ground are provided to compensate for the inevitable peaking which is due to stray feed-forward which is most objectionable on the two highest voltage ranges.

7. The operational rectifier provides sharp half-wave rectification and gain. Input negative half-cycles produce a positive half-wave rectified sine wave at A. The feedback ratio is adjusted to provide a peak output voltage of 3.14 volts for a 10 microampere RMS input signal.

8. Subsequent RC filtering leaves only the DC Component. The RC network is multi-pole to minimize ripple content without introducing excessive response time delays. The source impedance seen by the DC preamplifier looking back into the LP filter is 100K, so as to maintain the source impedance balance required for good zero-stability.

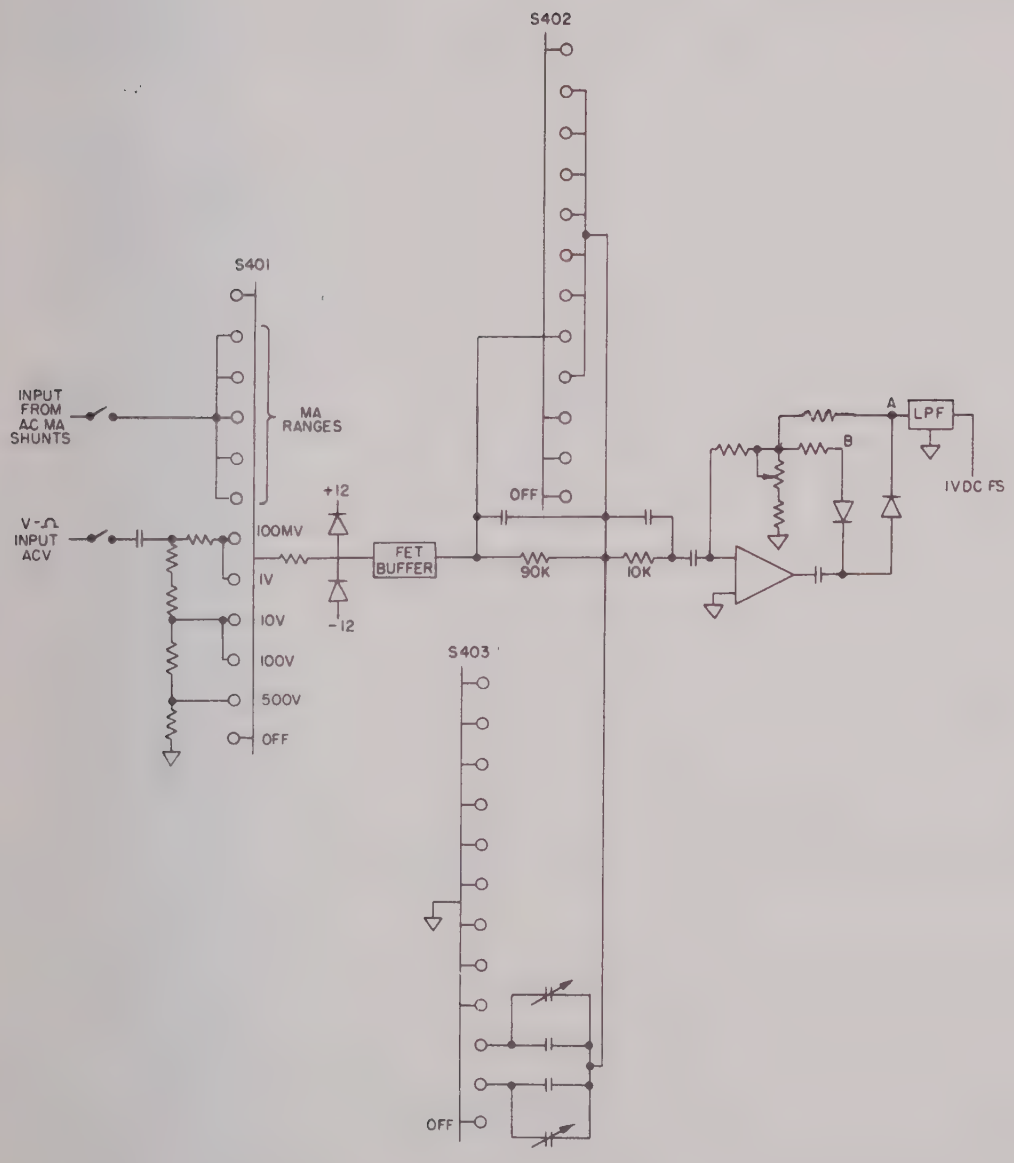


Figure 21. A.C. Converter Circuit

When AC current is being measured, the shunt network on the mother board converts it to 100 mV full scale and presents it to the converter through S401. Since all current ranges present 100 mV full scale, the 90K resistor in the rectifier input network remains shorted for all ranges.

POWER SUPPLY

The power supply circuit of Model 1242 provides a regulated ±12 volt source for the analog and reference circuitry, and a regulated 5 volt source for the digital circuits. In addition, a halfwave rectifier supplies an unfiltered high voltage supply for the numeral display tubes and neon indicators.

Low TC reference zeners are included as part of the power supply, and serve both to regulate the supply and as a reference source for the A/D converter. Current loads on the ±12 volt supply are balanced to maintain the reference diode operating points at the point of minimum T.C.

Regulation with respect to line is adequate for operation over +15% to -10% line voltage variations.

Two nominal line voltage levels of 115 V and 230 volts have been accommodated by a rear panel switch changing the primary winding connections from parallel to series-aiding.

A supplementary winding has been added to the transformer to provide energy for recharging a battery in the battery pack accessory, and to serve as part of the DC to AC Converter, provided with the battery pack. By making the converter winding part of the power transformer, converted battery power automatically replaces AC line power. A schematic diagram of the power supply will be found in Figure 27 in the maintenance section.

MAINTENANCE

In the course of normal operation, the Model 1242 should require no maintenance other than the occasional replacement of indicator lamps or overload protection fuses. Faulty operation may often be traced to improper settings of controls. A brief list of potential symptoms and suggested remedies is in order.

1. Power Fuse blown out - check setting of 115 V/230 V switch on rear panel. If line voltage is 230 volts, the switch should be set accordingly.
2. Half-bright or ill-defined display - rear panel switch may be set to 230 volts on a 115 V AC line.
3. Dim or partially defined digits on one or more indicator tubes - normal wear condition of numeral glow tube. Numeral tubes may be replaced after removing the window, a flexible panel which will be removed and reinserted by curving it about a horizontal axis.
4. Dim neon bulb indicators ("-", 1, ↑) - this is a normal wear condition. Neon indicator may be easily unsoldered for replacement since they are assembled with eyelets. See Installation Panel Mounting for instructions on Front Removal.
5. Runaway display - this is indicative of an open in the input circuit to the A/D converter. Either all push-buttons are up, or the situation is a normal result of operating on the two lowest AC or DC voltage ranges. If the test leads are no terminated in a return path, the display will escalate uncontrollably. Check the circuit being measured for continuity.

TEST EQUIPMENT REQUIRED

The following table lists the test equipment required for checking performance or calibration. It is important to use instruments of adequate accuracy and with a recalibration period sufficient to assure confidence in the results.

TEST EQUIPMENT

EQUIPMENT	PURPOSE	REQUIRED SPECIFICATION
DC Voltage Standard	DC Voltage Calibration	Accuracy: ±.003% rdg Range: 1 mV to 1000 V
DC Current Standard	DC Current Calibration	Accuracy: ±0.02% rdg Range: 10 microamperes to 1 ampere
AC Voltage Standard	AC Voltage Calibration	Accuracy: ±0.05% rdg Range: 10 mV to 500 V 40 Hz to 20KHz
AC Current Standard	AC Current Calibration	Accuracy: ±0.1% rdg Range: 10 microamperes to 1 ampere 40 Hz to 10KHz
Resistance Standard	Resistance Calibration	Accuracy: ±0.02% rdg Range: 100 ohms to 10 megohms

PERFORMANCE CHECK

To verify the specifications of the Model 1242, the following performance check is recommended.

Where reference standards are required, it is important to use units of adequate accuracy and with a recalibration period sufficient to assure confidence in the results.

DC VOLTAGE ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt operation as required, and install jumper plug on card-edge connector.
2. Connect power cord to instrument and AC power source.
3. Set range switch to 100 millivolt position.
4. Depress function push button DC (V-Ω) to the down position.
5. Insert test leads in jacks V-Ω and COM. Allow a warm-up time of approximately 60 minutes to assure best results.
6. With test leads shorted, adjust the zero control on the front until the display reads 00.00.
7. Set output of DC voltage standard to zero. Connect V-Ω and COM leads on the Model 1242 to (+) and (-) output terminals respectively on voltage standard.
8. Referring to the following table, set voltage standard to output levels tabulated. Set power/range switch to its appropriate setting on Model 1242. Check to insure that readout falls within the limits specified, if not refer to the appropriate calibration procedure.

DC VOLTAGE ACCURACY AT
REFERENCE CONDITIONS

Voltage Input	Range Switch Setting	Readout Limits	
		Min.	Max.
Input Shorted ±1.0 mV ±10 mV ±100 mV	100 mV	00.00 ±00.99 ± 9.98 ±99.94	±00.01 ±01.01 ±10.02 ±100.06
Input Shorted ±1 Volt	1 Volt	0.000 ±0.9994	±0.001 ±1.0006
±10 Volt	10 Volt	±9.994	±10.006
±100 Volt	100 Volt	±99.94	±100.06
±1000 Volt	1000 Volt	±999.4	±1000.6

RESISTANCE ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt AC line operation as required, and install the jumper plug on the card-edge connector.
2. Connect power cord to instrument and AC power source.
3. Depress function push button DC (V-Ω) to the down position.
4. Set range switch to the 100 mV range.
5. Insert test leads in jacks V-Ω and COM. Allow a warm-up time of approximately 60 minutes to achieve best results before testing.
6. With test leads shorted, adjust the zero control on the front until the display reads 00.00. The meter is now ready for resistance measurement.

NOTE

When checking the 1KΩ range for accuracy, it will be necessary to rezero the meter to compensate for test lead resistance.

7. Connect meter to resistance standard.
8. Referring to the following table, set resistance standard to values listed. Set Model 1242 range switch to the proper range. Check to insure readout is within the limits given, if not refer to calibration procedure.

RESISTANCE ACCURACY AT
REFERENCE CONDITIONS

Resistance Standard	Range Switch Setting	Readout Limits	
		Min.	Max.
Input Shorted 1KΩ	1KΩ	.0000 .9984	±.0001 1.0016
10KΩ	10KΩ	9.989	10.011
100KΩ	100KΩ	99.89	100.11
1MΩ	1MΩ	.9974	1.0026
10MΩ	10MΩ	9.949	10.051

DC CURRENT ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt line operation, as required, and install the jumper plug on the card-edge connector.
2. Connect power cord to instrument and AC power source.
3. Set range switch to the 100 mV range.
4. Depress function push button DC V-Ω.
5. Insert test leads in mA and COM jacks. Allow a warm-up time of approximately 60 minutes to achieve best results before testing.
6. With no leads attached, adjust the zero control for a reading of 00.00. The instrument is now ready for current testing.
7. Set output of DC current standard to zero. Connect mA and COM leads on the Model 1242 to (+) and (-) output terminals respectively on current standard.
8. Referring to following table set current standard to values listed. Set Model 1242 range switch to the proper range. Check to insure readout is within the limits given.

DC CURRENT ACCURACY AT
REFERENCE CONDITIONS

DC Current Input	Range Switch Setting	Readout Limits	
		Min.	Max.
0	100μA	00.00	±00.01
±100.00μA		±99.84	±100.16
±1.0000mA	1mA	±.9984	±1.0016
±10.000mA	10mA	±9.840	±10.016
±100.00mA	100mA	±99.84	±100.16
±1000.0mA	1000mA	±998.4	±1002.1

AC VOLTAGE ACCURACY CHECK

1. Set the line voltage selector switch on the rear of the instrument for 115 or 230 volt AC line operation as required, and install the jumper plug on the card-edge connector.
2. Connect power cord to instrument and AC power source.
3. Set range switch to 100 mV position.
4. Depress function push button DC V-Ω to the down position.
5. Insert test leads in V-Ω and COM jacks. Allow a warm-up time of 60 minutes to obtain best results.
6. Short the input leads and adjust the zero control for a reading of 00.00. The instrument is now ready for AC volts testing.
7. Set AC voltage standard to zero. Connect V-Ω and COM leads on the Model 1242 to the output terminals on AC voltage standard.
8. Referring to the following table set voltage standard to output levels tabulated. To fully check AC voltage performance tests at the tabulated levels should be made at frequencies of 40Hz, 60Hz, 400Hz, 10KHz and 20KHz. Set the range switch on the Model 1242 to its appropriate setting. Check to insure that the readout falls within the limits specified.

AC VOLTAGE ACCURACY AT
REFERENCE CONDITIONS

AC Voltage Input	Range Switch Setting	Readout Limits 40Hz Min.	40Hz Max.	60Hz to 10KHz Min.	60Hz to 10KHz Max.	20KHz Min.	20KHz Max.
00.00 100.00mV	100mV	00.00 99.70	00.05 100.30	00.00 99.75	00.05 100.25	00.00 99.45	00.05 100.55
.10000V 1.0000 V	1V	.0992 .9970	.1008 1.0030	.0993 .9975	.1007 1.0025	.0990 .9945	.1010 1.0055
1.000 V 10.000 V	10V	.992 9.970	1.008 10.030	.993 9.975	1.007 10.025	.0990 9.945	1.010 10.055
10.00 V 100.00 V	100V	9.92 99.70	10.08 100.30	9.93 99.75	10.07 100.25	9.90 99.45	10.10 100.55
500.0 V	500V	499.3	500.7	498.5	501.5	497.0	503.0

AC CURRENT ACCURACY CHECK

1. Set line voltage selector switch on the rear of the instrument, for 115 or 230 volt AC line operation as required, and install the jumper plug on the card-edge connector.
2. Connect power cord to instrument and AC power source.
3. Set range switch to 100 mV position.
4. Depress function push button DC V-Ω to the down position.
5. Insert test leads in V-Ω and COM jacks. Allow a warm-up time of 60 minutes to obtain best results.
6. Short the input leads and adjust the zero control for a reading of 00.00. The instrument is now ready for AC current testing.
7. Set AC current standard to zero. Connect mA and COM leads on the Model 1242 to the output terminals of the current standard.
8. Referring to the following table set current standard to output levels tabulated. (To fully check AC current, performance tests at the tabulated levels should be made at frequencies of 40Hz, 60Hz, 400Hz and 10KHz.) Set range switch on the Model 1242 to its appropriate setting. Check to insure that the readout falls within the limits specified.

AC CURRENT ACCURACY AT
REFERENCE CONDITIONS

AC Current Input	Range Switch Setting	Readout Limits 40Hz to 10KHz	
		Min.	Max.
00.00μa 100.0μa	100μa	00.00 99.60	00.05 100.40
1.0000mA	1mA	.9960	1.0040
10.000mA	10mA	9.960	10.040
100.00mA	100mA	99.60	100.40
1000.0mA	1000mA	995.5	1004.5

If any of the performance checks fail, a recalibration may be required. Meter should be warmed up 60 minutes before calibrating. The starting point of any recalibration is the setting of zero. This should be done on the 100 mV DC range with the input leads shorted.

NOTE

Linking terminals is preferable, if possible.

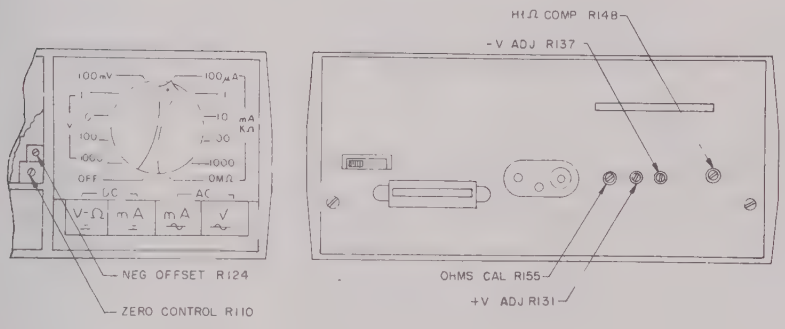


Figure 22. Calibration

1. R110 should be adjusted for a reading of -00.00, and then backed off until the "-" sign extinguishes. This procedure will be adequate for all routine zero adjustment. Zero readings on all other DC voltage ranges and on all DC MA ranges should be within 1 digit of zero. If not, due to internal drifts with time, a more critical adjustment of zero can be made as follows.
2. With the input leads shorted and the DC V-Ω button depressed, switch back and forth between 100mV and 1 volt range positions, adjusting R110 until the reading is the same for both positions, even though that reading may not be zero.

3. Set the range switch to the 100mV position and apply -200 microvolts. Adjust R124 to read -20 counts. Switch the input signal to +200 microvolts. The display should read 20. (If it does not read 20 within ±1 count, an internal adjustment may be required, to insure maximum accuracy consult your local service center for guidance.) The zero is now set and full scale adjustments may now be made.

4. Set the input level to +190.00 mV. Adjust R131 for a reading of 19000 digits.

5. Set the input level to -190.00 mV. Adjust R137 for a reading of -19000 digits.

6. Set the range to 1 volt and apply +1.9000 volts. The display should read 1.9000 within rated accuracy. If not, the user has the option of offsetting the full scale adjustments to split the errors so that both ranges will be within specification or resorting to an internal gain adjustment which should have the guidance either from the factory or the local field service center.

7. Ohms calibration - Depress the DC V-Ω button and set the range switch to the 100KΩ position. Connect the test leads to a standard resistor of some value below 200KΩ but as high as possible for good setting resolution. Adjust R155 for a reading corres onding to the standard.

8. 10 Megohm range - Set the range switch to the 10 megohm position and measure a 10 megohms standard. Adjust R148 for a face value reading. Since settling time is long for the 10 MΩ range, rotate R148 in small increments and wait for the display to settle.

9. DC current accuracy is controlled by fixed resistors and is not adjustable.

10. AC calibration requires internal adjustments. Consult the factory or your local service center.

11. AC current calibration is the product of items 9 and 10 above and requires internal adjustments.

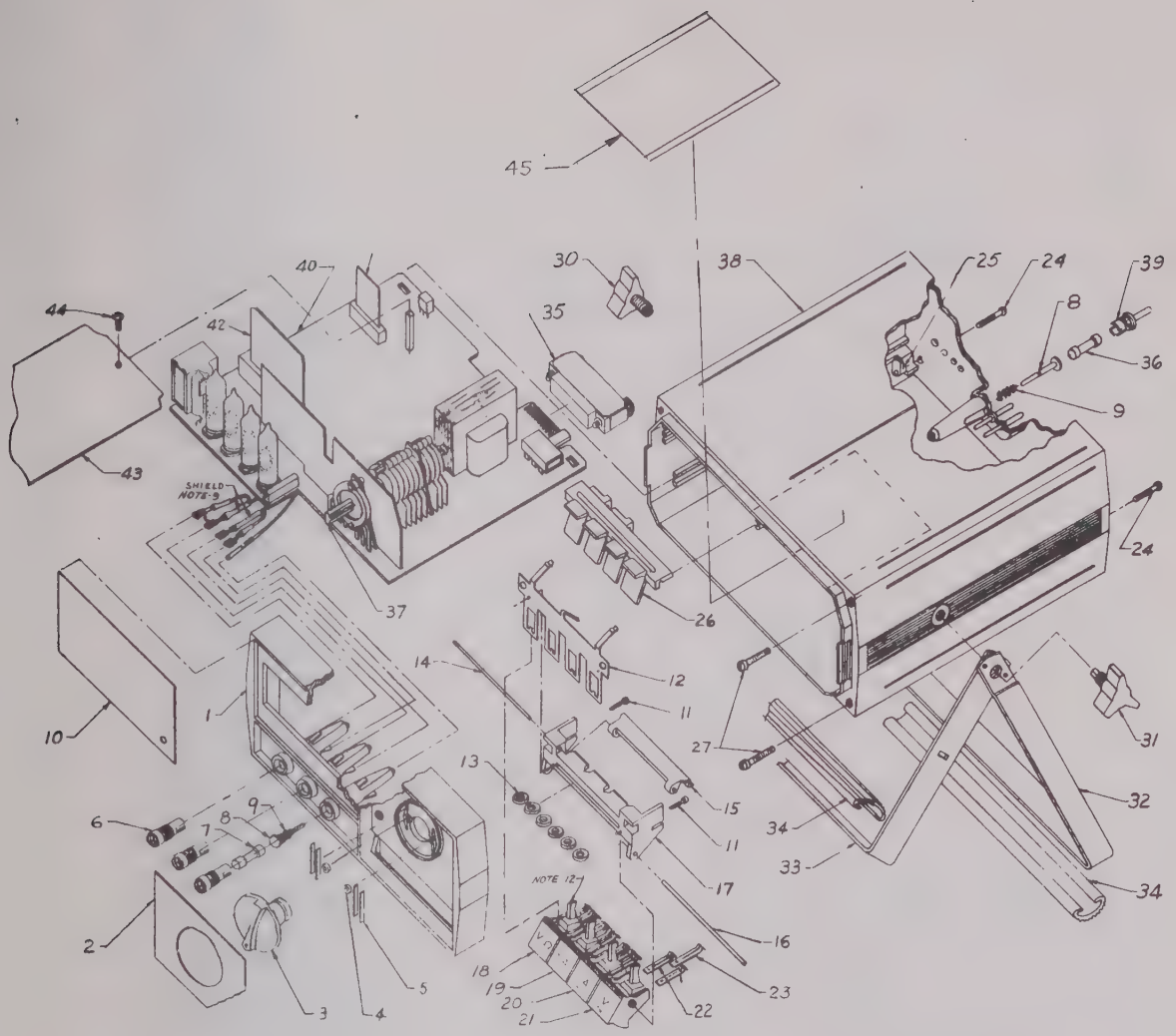


Figure 23. Method of Assembly

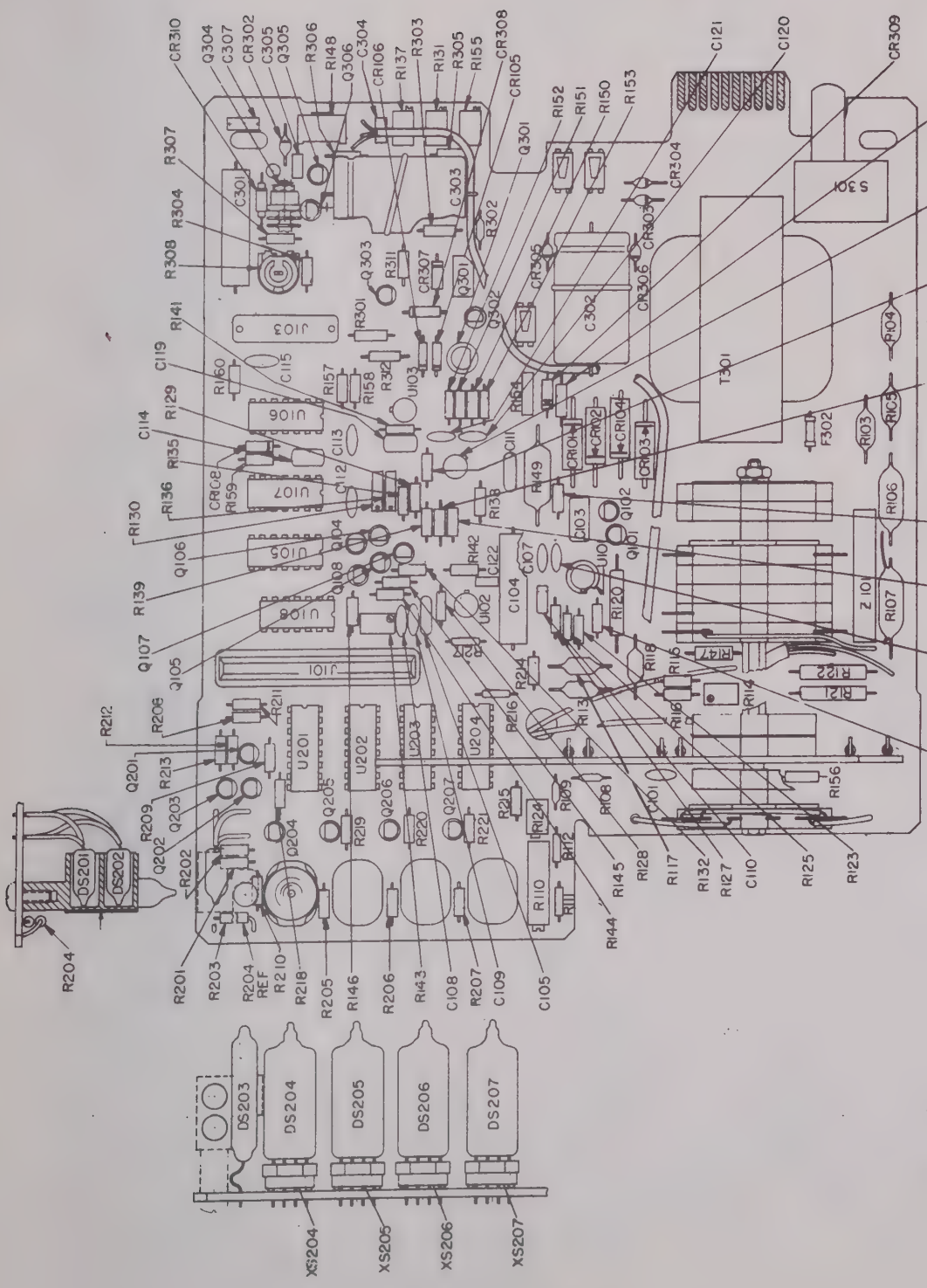


Figure 24. Board Assembly

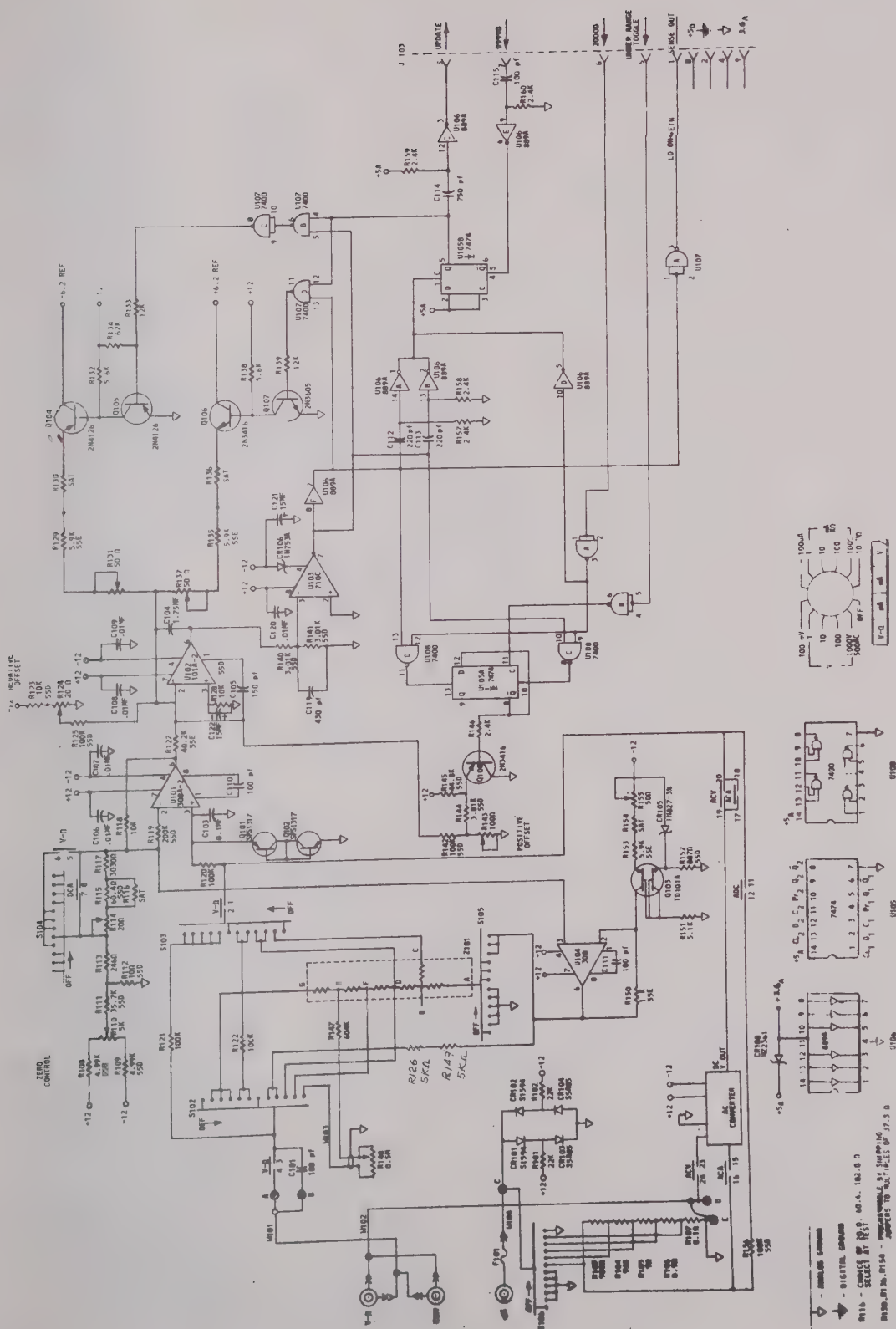


Figure 25. Schematic Diagram, Analog Section

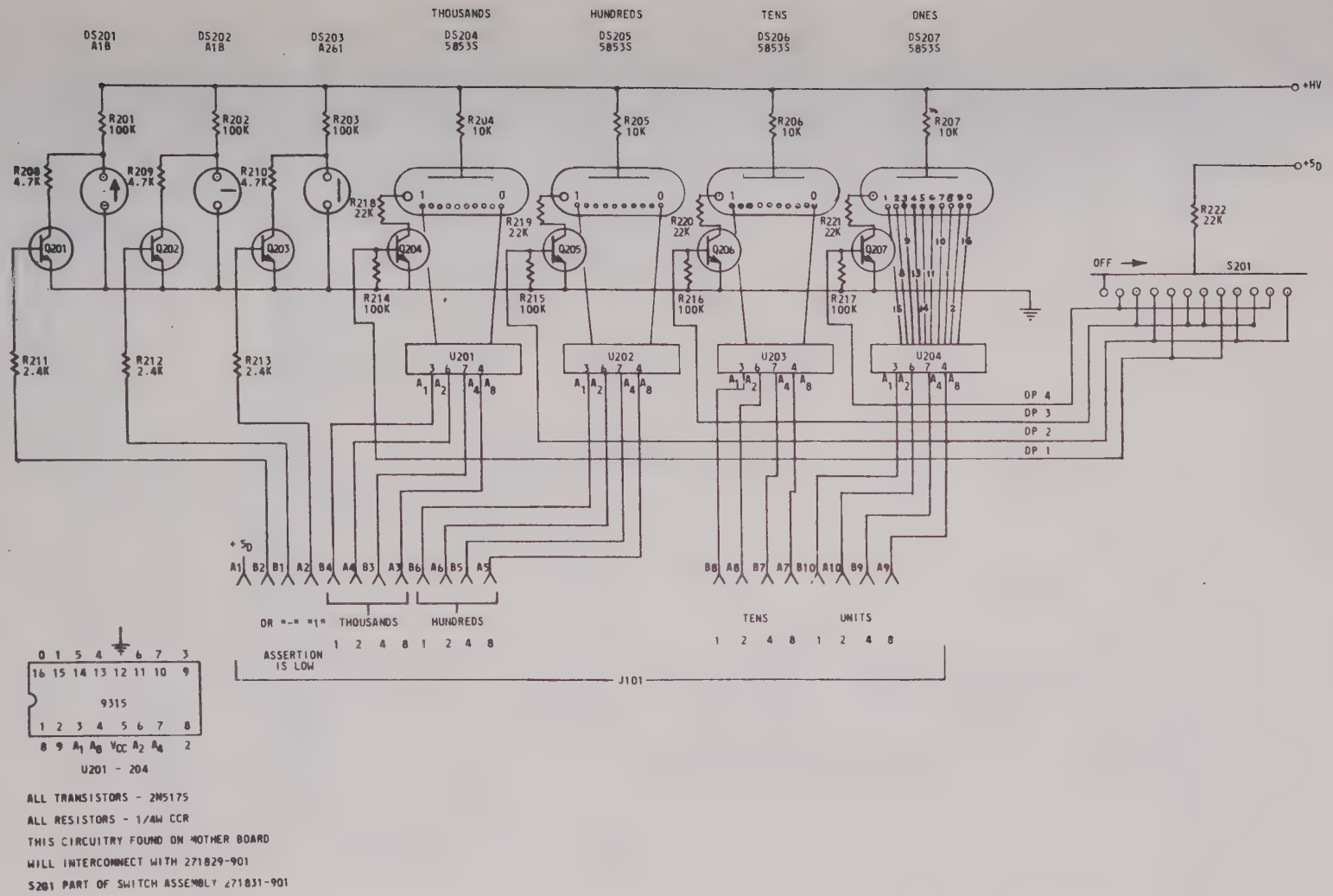


Figure 26. Schematic Diagram, Display Circuit

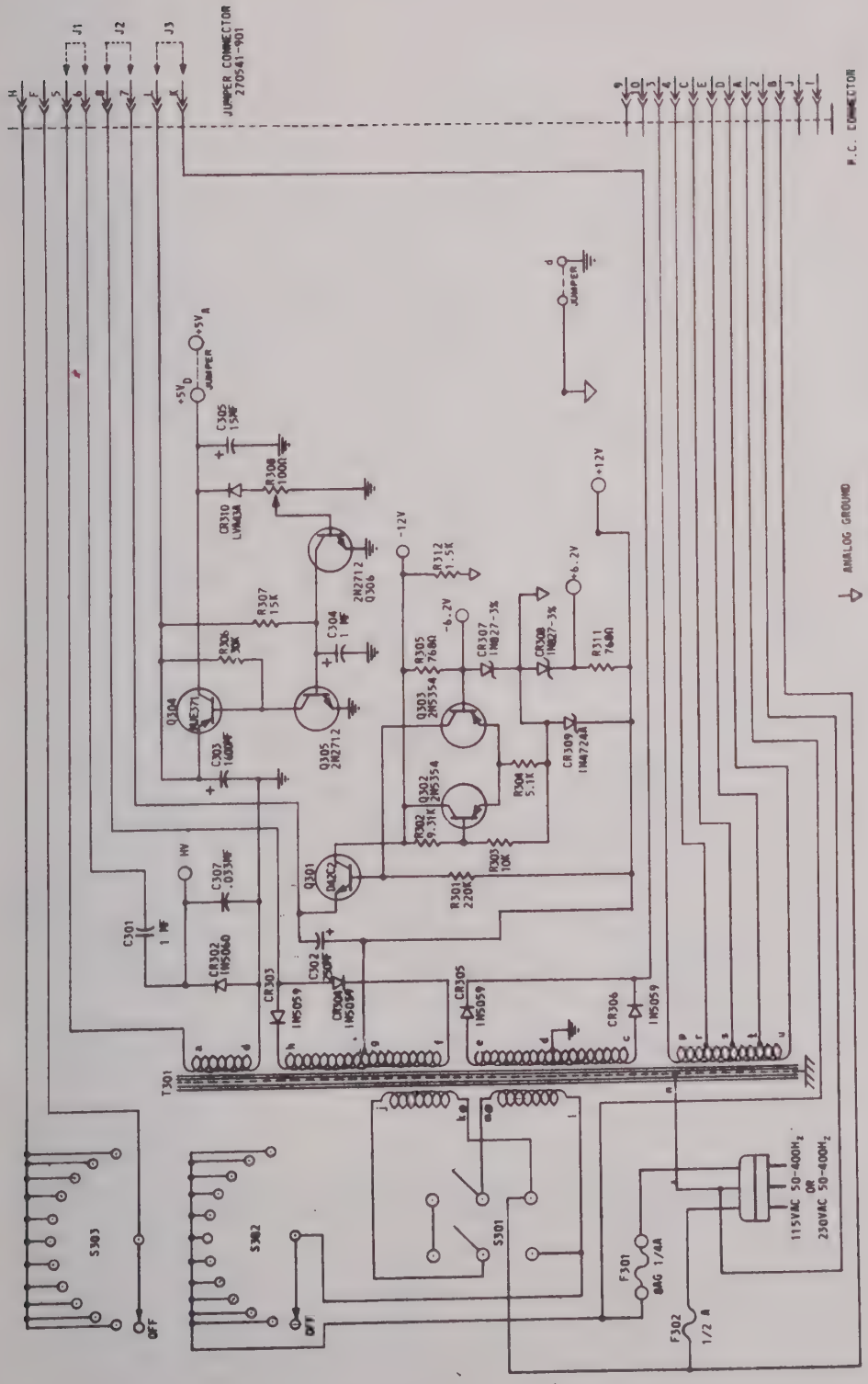


Figure 27. Schematic Diagram, Power Supply

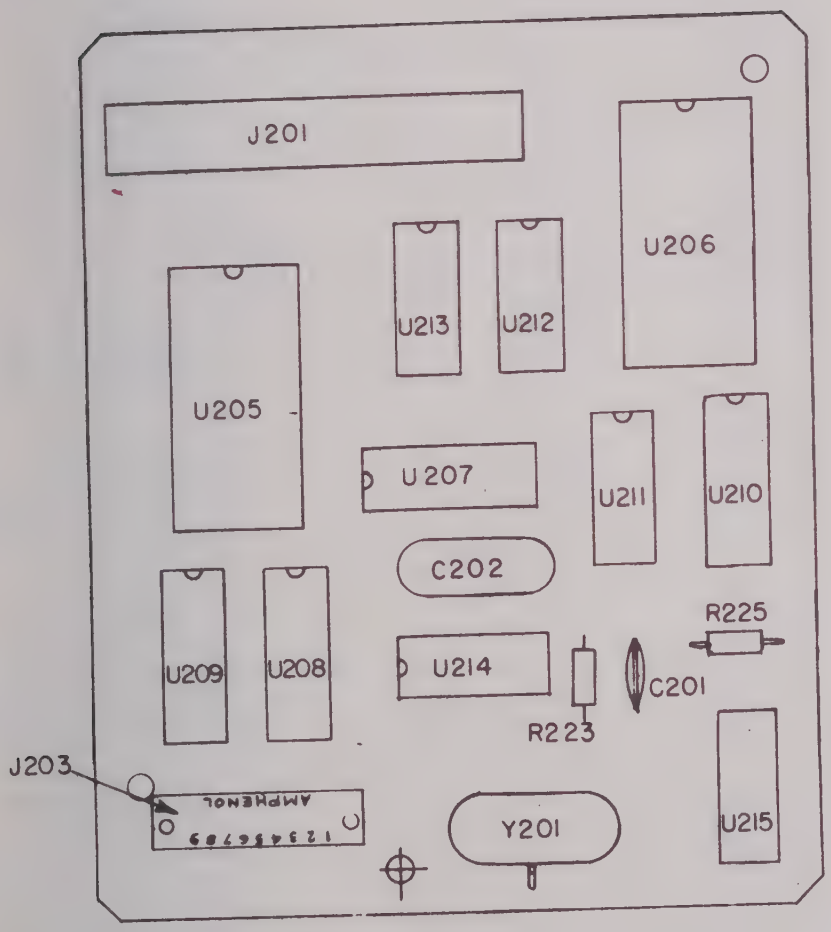


Figure 28. Board Assembly, Logic

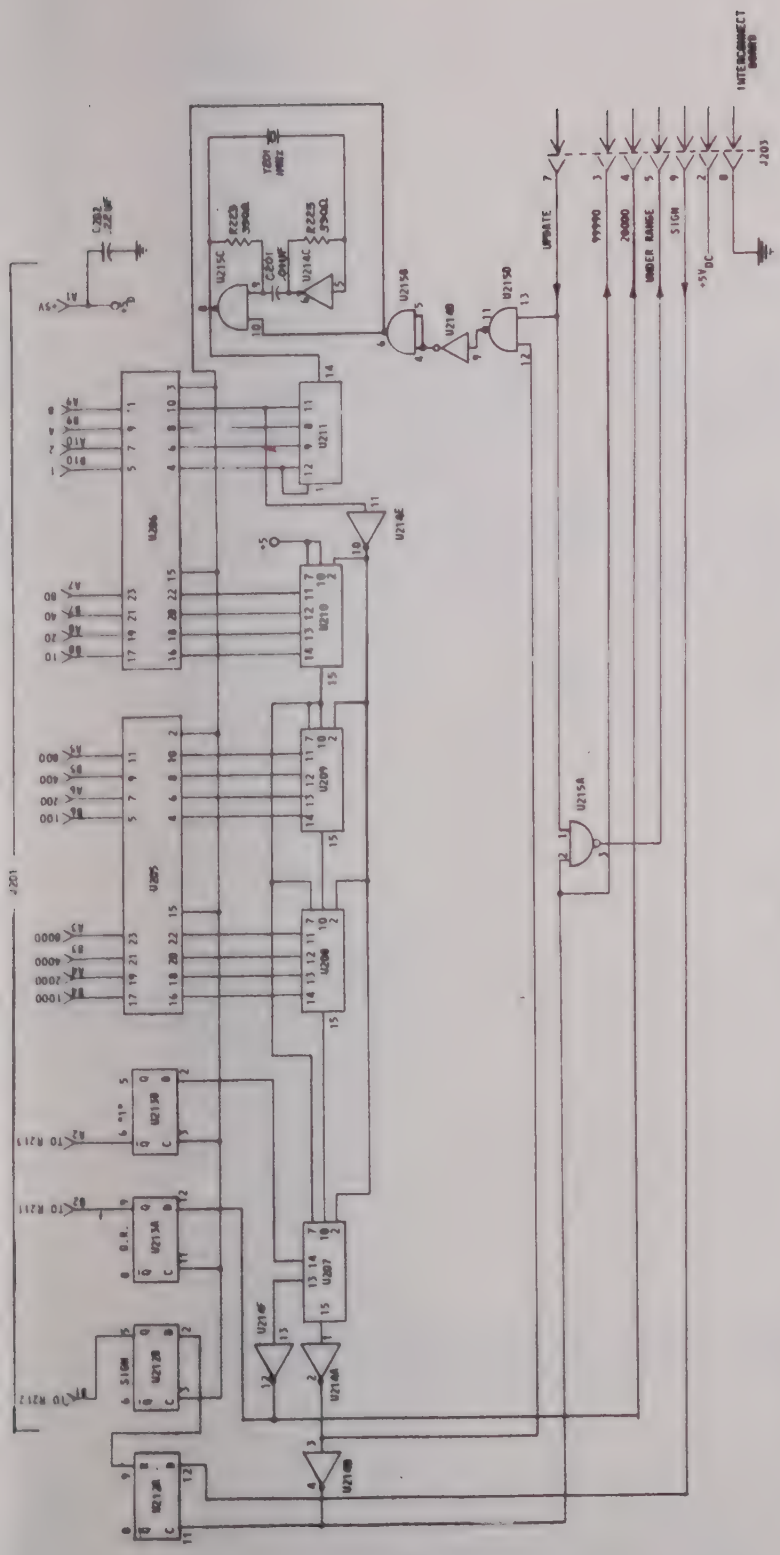


Figure 29. Schematic Diagram, Logic Section

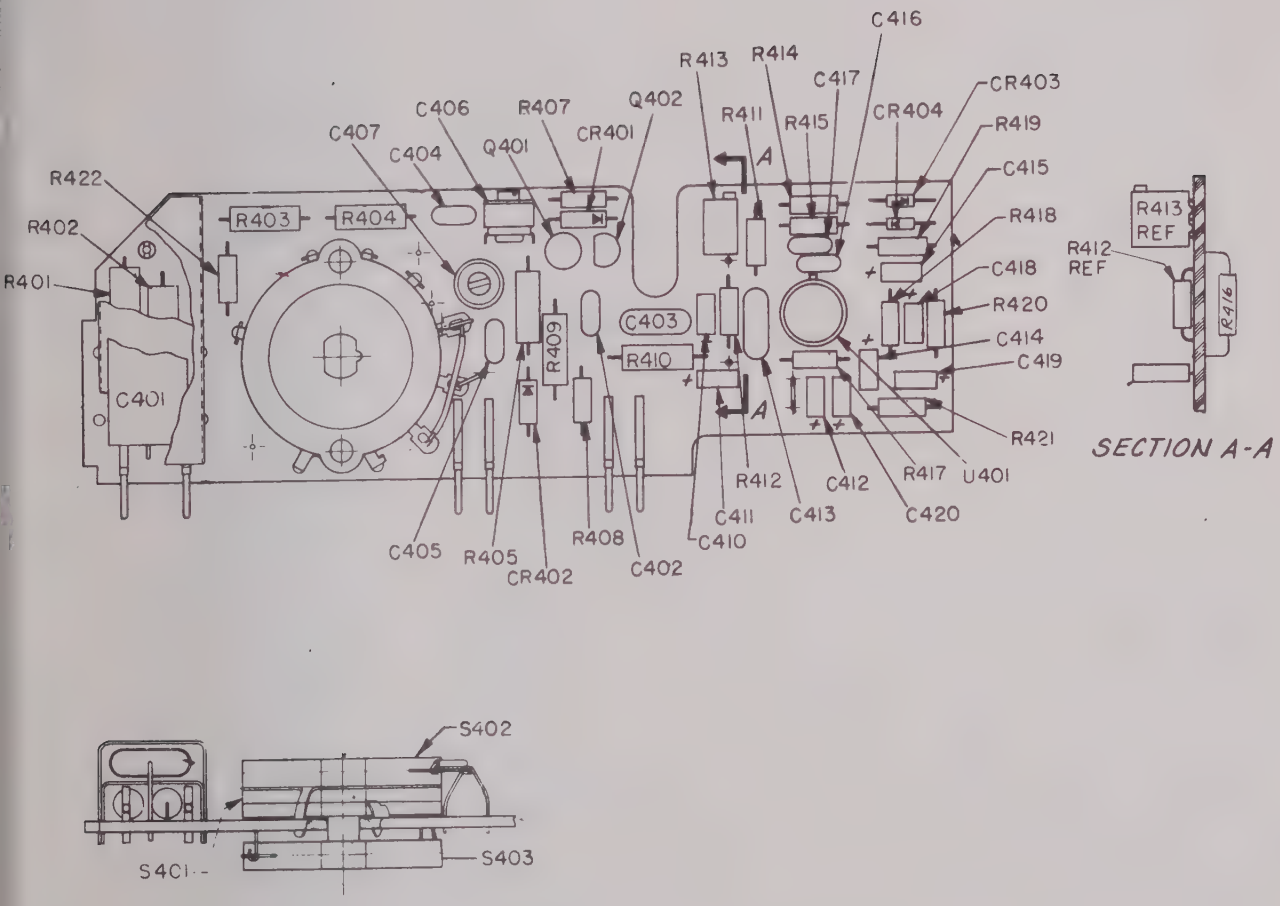


Figure 30. Board Assembly, AC Converter

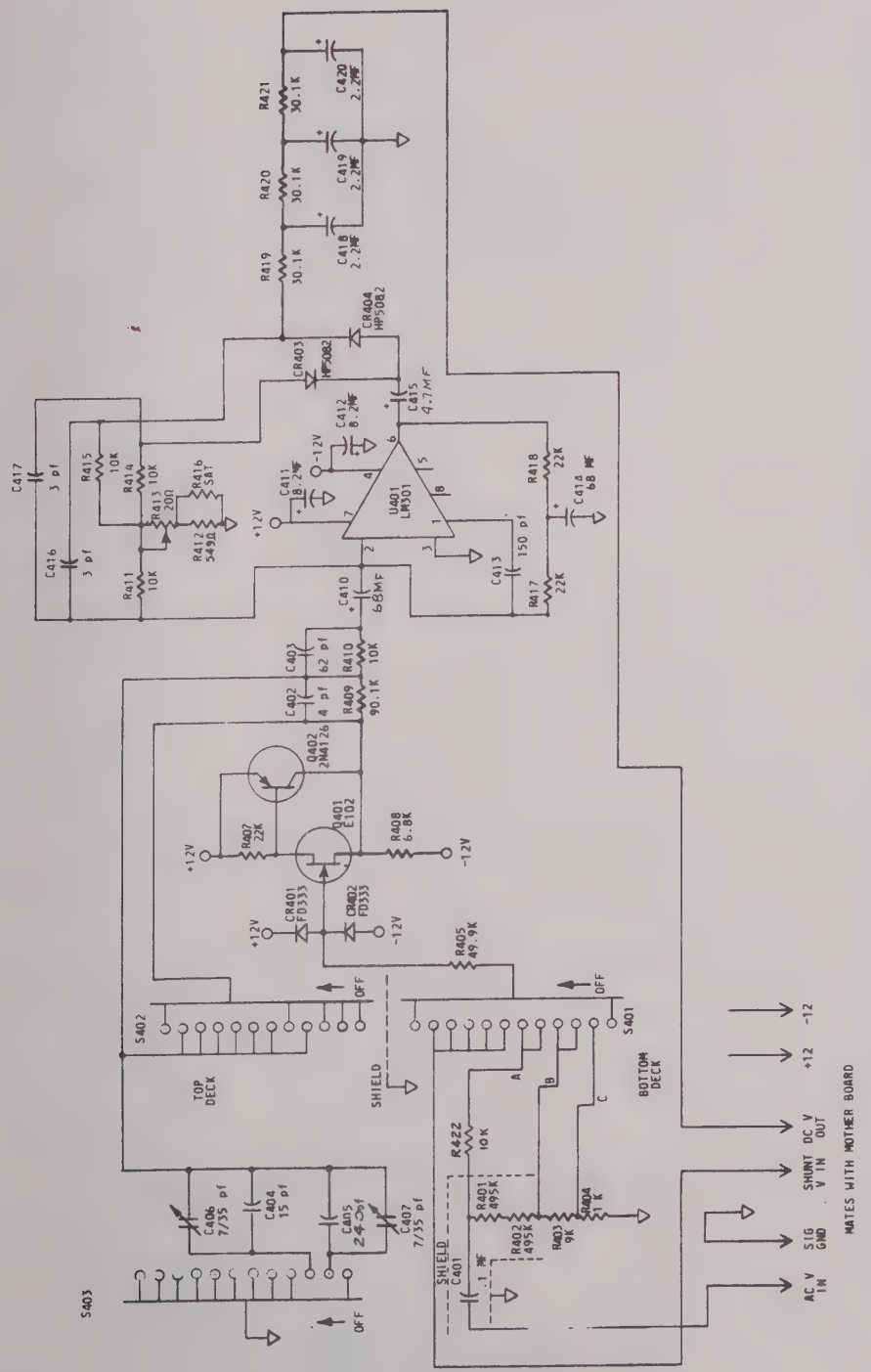


Figure 31. Schematic Diagram, AC Converter

PARTS LIST

ITEM NO.	DESCRIPTION	WESTON PART NO.
	ASSEMBLY (See Figure 23)	
1	FRONT, MOLDED	267327-901
2	DIAL, PRINTED	271795-901
3	KNOB	267331-901
4	ROLLER, DETENT	267334-001
5	SPRING, DETENT	267333-001
6	SOCKET, BANANA PLUG	267330-024
7	FUSE, INPUT, 3 AMP, 8AG	269938-001
8	CONTACT, BANANA PLUG	269062-001
9	SPRING	270006-172
10	WINDOW	267328-907
11	SCREW	ND27395-045
12	SPRING, BUTTON RETURN	267338-001
13	ROLLER, INTERLOCK	267337-001
14	SHAFT, LOCK	267341-001
15	LOCK, BUTTON	267340-001
16	SHAFT, BUTTON	267339-001
17	SUPPORT, INTERLOCK	267336-001
18	BUTTON, SWITCH, V - Ω =	270975-903
19	BUTTON, SWITCH mA =	270975-901
20	BUTTON, SWITCH mA ≂	270975-902
21	BUTTON, SWITCH V ≂	270975-904
22	CONTACT, OUTER	267342-077
23	CONTACT, CENTER	267343-077
24	SCREW, Circuit Board Mtg	266623-045
25	CLAMP, Circuit Board Mtg	265661-024
26	CLAMP, TUBE	271800-001
27	SCREW, Panel Mtg	ND32910-024
28	LEAD ASSY, TEST (Not shown)	270066-001
29	LINE CORD (Not shown)	269985-001
30	KNOB, HANDLE	269546-001
31	KNOB, HANDLE	269547-001
32	HANDLE, REAR	267346-366
33	HANDLE, FRONT	267345-366
34	GRIP, HANDLE	267347-902
35	CONNECTOR ASSY	270541-901
36	FUSE, AC PLUG, 1/4 AMP 8AG	ND29787-001
37	SHAFT, RANGE SWITCH	269436-001
38	CASE	269444-903
39	PIN, AC FUSE	269066-001
40	BOARD ASSY	271810-901
41	BOARD, INTERCONNECT, REAR	271846-901
42	BOARD, INTERCONNECT, FRONT	271845-901
43	BOARD ASSY, LOGIC	271829-901
44	SCREW	ND24126-024
45	SHIELD ASSY	271891-901

PARTS LIST

REF SYMBOL	DESCRIPTION	WESTON PART NO.
	BOARD ASSEMBLY (Ref Figure 24 thru 27)	
C101	CAPACITOR, 100 pF, 1000 WVDC	264089-001
C103	CAPACITOR, 0.1 µF, 250 WVDC	269900-001
C104	CAPACITOR, 1.75 µF, 100 WVDC	269897-001
C105	CAPACITOR, 150 pF, 500 WVDC	265869-001
C106	CAPACITOR, 0.01 µF, 50 WVDC	269899-001
C107	CAPACITOR, 0.01 µF, 50 WVDC	269899-001
C108	CAPACITOR, 0.01 µF, 50 WVDC	269899-001
C109	CAPACITOR, 0.01 µF, 50 WVDC	269899-001
C110	CAPACITOR, 100 pF, 1000 WVDC	264089-001
C111	CAPACITOR, 100 pF, 1000 WVDC	264089-001
C112	CAPACITOR, 200 pF, 1000 WVDC	264091-001
C113	CAPACITOR, 200 pF, 1000 WVDC	264091-001
C114	CAPACITOR, 750 pF, 500 WVDC	265884-001
C115	CAPACITOR, 100 pF, 1000 WVDC	264089-001
C119	CAPACITOR, 430 pF, 500 WVDC	270079-001
C120	CAPACITOR, 0.01 µF, 50 WVDC	269899-001
C121	CAPACITOR, 15 µF, 10 WVDC	269951-001
C122	CAPACITOR, 15 µF, 10 WVDC	269951-001
C301	CAPACITOR, 1 µF, 200 WVDC	269895-001
C302	CAPACITOR, 250µF, 64 WVDC	266349-001
C303	CAPACITOR, 1600 µF, 10 WVDC	266607-001
C304	CAPACITOR, 1 µF, 35 WVDC	269954-001
C305	CAPACITOR, 15 µF, 10 WVDC	269951-001
C307	CAPACITOR, 0.033 µF, 200 WVDC	272881-001
CR101	DIODE, S1594	272775-001
CR102	DIODE, S1594	272775-001
CR103	DIODE, S5A05	272364-001
CR104	DIODE, S5A05	272364-001
CR105	DIODE, 1N827-3%	272774-001
CR106	DIODE, 1N753A	264699-001
CR108	DIODE, MZ2361	272830-001
CR302	DIODE, 1N5060	266591-001
CR303	DIODE, 1N5059	266611-001
CR304	DIODE, 1N5059	266611-001
CR305	DIODE, 1N5059	266611-001
CR306	DIODE, 1N5059	266611-001
CR307	DIODE, 1N827-3%	272774-001
CR308	DIODE, 1N827-3%	272774-001
CR309	DIODE, 1N4742A	264601-001
CR310	DIODE, LV43A	272737-001

PARTS LIST

REF SYMBOL	DESCRIPTION	WESTON PART NO.
DS201	LAMP, GE A1B	269877-001
DS202	LAMP, GE A1B	269877-001
DS203	LAMP, NEON, SIGNALITE A261	266537-001
DS204	TUBE, READOUT, BURROUGHS B5853S	272589-001
DS205	TUBE, READOUT, BURROUGHS B5853S	272589-001
DS206	TUBE, READOUT, BURROUGHS B5853S	272589-001
DS207	TUBE, READOUT, BURROUGHS B5853S	272589-001
F302	FUSE, 1/2 AMP, LITTELFUSE 276.500	272753-001
J101	CONNECTOR	272779-001
J103	CONNECTOR, AMPHENOL 64-17	272780-001
Q101	TRANSISTOR, SPS1317	270075-001
Q102	TRANSISTOR, SPS1317	270075-001
Q103	INTEGRATED CIRCUIT, TD101A	266399-001
Q104	TRANSISTOR, 2N4126	269956-001
Q105	TRANSISTOR, 2N4126	269956-001
Q106	TRANSISTOR, 2N3416	263642-001
Q107	TRANSISTOR, 2N3605	268796-001
Q108	TRANSISTOR, 2N3416	263642-001
Q201	TRANSISTOR, 2N5175	266585-001
Q202	TRANSISTOR, 2N5175	266585-001
Q203	TRANSISTOR, 2N5175	266585-001
Q204	TRANSISTOR, 2N5175	266585-001
Q205	TRANSISTOR, 2N5175	266585-001
Q206	TRANSISTOR, 2N5175	266585-001
Q207	TRANSISTOR, 2N5175	266585-001
Q301	TRANSISTOR, D42C2N	269902-001
Q302	TRANSISTOR, 2N5354	268795-001
Q303	TRANSISTOR, 2N5354	268795-001
Q304	TRANSISTOR, MJE371	266343-001
Q305	TRANSISTOR, 2N2712	39917-001
Q306	TRANSISTOR, 2N2712	39917-001
R101	RESISTOR, 22K ohms, ±5%, 1/4 watt	264674-001
R102	RESISTOR, 22K ohms, ±5%, 1/4 watt	264674-001
R103	RESISTOR, 900 ohms, ±0.1%, 1/4 watt	269942-001
R104	RESISTOR, 90 ohms, ±0.1%, 1/4 watt	269941-001
R105	RESISTOR, 9 ohms, ±0.1%, 1/4 watt	269940-001
R106	RESISTOR, 0.9 ohm, ±0.1%, 1/2 watt	269939-001

PARTS LIST

REF SYMBOL	DESCRIPTION	WESTON PART NO.
R107	RESISTOR, 0.1 ohms, ±0.1%, 2 1/2 watt	269943-001
R108	RESISTOR, 4.99K ohms, ±1%, 1/10 watt	269911-001
R109	RESISTOR, 4.99K ohms, ±1%, 1/10 watt	269911-001
R110	RESISTOR, VARIABLE, 5K ohms, ±10%, 1 watt	269919-001
R111	RESISTOR, 35.7K ohms, ±1%, 1/10 watt	270158-001
R112	RESISTOR, 10 ohms, ±1%, 1/10 watt	269915-001
R113	RESISTOR, 246 ohms, ±0.5%, .166 watt	272763-001
R114	RESISTOR, VARIABLE, 20 ohms, ±5%, .6 watt	272805-001
R115	RESISTOR, 60.4 ohms, ±1%, 1/10 watt	272770-001
R116	RESISTOR, KIT	271820-901
R117	RESISTOR, 3030 ohms, ±0.5%, .166 watt	272761-001
R118	RESISTOR, 10K ohms, ±0.5%, .166 watt	272762-001
R119	RESISTOR, 200K ohms, ±1%, 1/10 watt	272768-001
R120	RESISTOR, 100K ohms, ±1%, 3/4 watt	269912-001
R121	RESISTOR, 100K ohms, ±1%, 3/4 watt	269912-001
R122	RESISTOR, 100K ohms, ±1%, 3/4 watt	269912-001
R123	RESISTOR, 10K ohms, ±1%, 1/10 watt	269887-001
R124	RESISTOR, VARIABLE, 20 ohms, ±5%, .6 watt	272781-001
R125	RESISTOR, 100K ohms, ±1%, 1/10 watt	269885-001
R127	RESISTOR, 40.2K ohms, ±1%, 1/10 watt	272773-001
R128	RESISTOR, 10K ohms, ±1%, 1/10 watt	269887-001
R129	RESISTOR, 5.9K ohms, ±1%, 1/10 watt	272772-001
R130	RESISTOR, NETWORK TRIMMING	271853-001
R131	RESISTOR, VARIABLE, 50 ohms, ±5%, .6 watt	270003-001
R132	RESISTOR, 5.6K ohms, ±5%, 1/4 watt	265819-001
R133	RESISTOR, 12K ohms, ±5%, 1/4 watt	266613-001
R134	RESISTOR, 62K ohms, ±5%, 1/4 watt	263651-001
R135	RESISTOR, 5.9K ohms, ±1%, 1/10 watt	272772-001
R136	RESISTOR, NETWORK TRIMMING	271853-001
R137	RESISTOR, VARIABLE, 50 ohms, ±5%	270003-001
R138	RESISTOR, 5.6K ohms, ±5%, 1/4 watt	265819-001
R139	RESISTOR, 12K ohms, ±5%, 1/4 watt	266613-001
R140	RESISTOR, 3.01K ohms, ±1%, 1/10 watt	272217-001
R141	RESISTOR, 3.01K ohms, ±1%, 1/10 watt	272217-001
R142	RESISTOR, 100K ohms, ±1%, 1/10 watt	269885-001
R143	RESISTOR, VARIABLE, 100 ohms, ±5%,	272807-001
R144	RESISTOR, 3.01K ohms, ±1%, 1/10 watt	272217-001
R145	RESISTOR, 44.8K ohms, ±1%, 1/10 watt	272213-001
R146	RESISTOR, 2.4K ohms, ±5%, 1/4 watt	266615-001
R147	RESISTOR, 604K ohms, ±1%, 1/10 watt	272765-001
R148	RESISTOR, VARIABLE, 0.5 megohms, ±10%, 1 watt	272777-001

ACCEPTED

MP MASTER
MA35433